EXHIBIT 18

e authoritative guide for executives, technology professionals and investors on pidly emerging IPTV systems, businesses, and trends.

TV and Internet Video clearly explains and demystifies the functions, markets, and ure impact of this exploding technology. This book contains an overview of hardware, ftware, and Internet technologies, as well as case studies that cover a range of products d services. It is a guide to help leaders master the key trends and drivers transforming the rld of broadcast television and the Web. Each piece of the puzzle is discussed in detail, m head ends, Web portals, and VOD servers, through advanced IP networks, DSLAMs d xDSL lines to viewers' set-top boxes and multimedia PCs. You'll get a working owledge of IPTV, enabling both non-technical and technical professionals to accurately alyze the emerging technology and business opportunities. Written by two leading gital media experts, each with 25 years technology development experience and global sight. This book also looks ahead to IPTV's rapid deployment and future growth.

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Reality Check perspectives in each chapter tie theory to real-world case studies
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Wes Simpson is President of Telecom Product Consulting, an independent consulting firm that focuses on video and telecommunications products. He has more than 25 years experience in the design, development and marketing of products for telecommunication applications. He is a frequent speaker at industry events such as IBC, NAB and VidTrans and is author of the book Video Over IP. Wes was a founding member of the Video Services Forum.

Howard Greenfield is a digital media strategist, industry columnist, and President of Go Associates, a leading global strategic business development consulting firm. Howard has held senior management and consulting positions with Sun Microsystems, Informix Software, British Telecom, and Apple Computer. He was the creator and leader of Sun's first Media Lab and completed graduate studies at Stanford University. He is a frequent contributor to technology and business publications and conferences world-wide.

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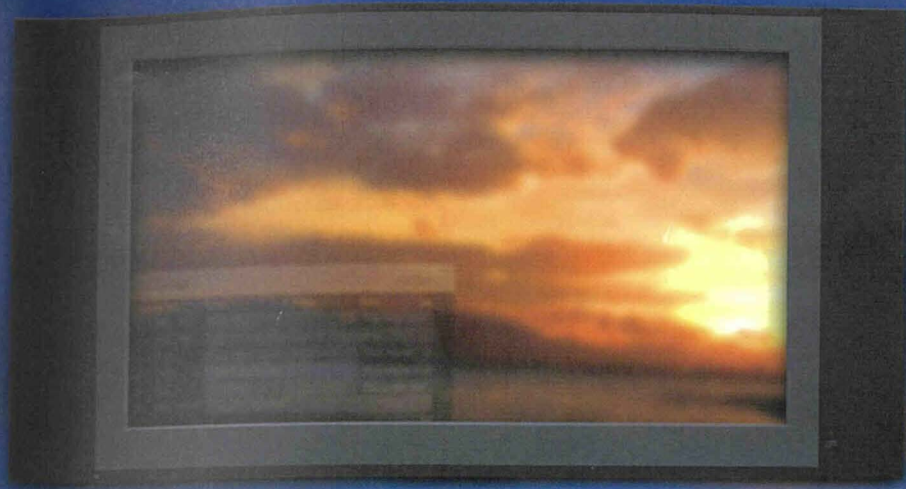

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IPTV and Internet Video

Expanding the Reach of Television Broadcasting

Wes Simpson and Howard Greenfield

National Association of NAB™

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Dedication

Thanks to my loving wife, Laurie, and our fantastic children, Taylor and Cameron, for giving me your support and gentle encouragement to embark on this fascinating journey.

—Wes Simpson

Dedicated to my parents, Sam and Rose Greenfield, for lifting me on their shoulders and keeping me in their great hearts.

—Howard Greenfield

About the Authors

Wes Simpson is president and founder of Telecom Product Consulting, an independent consulting firm that focuses on helping companies develop and market video and telecommunications products. He is a frequent speaker and analyst for the video transport marketplace; in the past three years alone he has spoken at IBC, NAB, BroadcastAsia, SMPTE, VidTrans and a number of other conferences. Wes is author of the well-received book "Video Over IP, A Practical User's Guide to Technologies and Applications" published by Focal Press in 2006.

Wes has more than 25 years experience in the design, development and marketing of products for telecommunication applications. Before founding Telecom Product Consulting, he was COO of VBrick Systems, Inc., a manufacturer of MPEG video equipment. Earlier, at ADC Telecommunications, Wes was the director of product management for the DV6000, a market leading video transport system. He previously held a variety of marketing and engineering positions in the telecommunications industry. Wes was a founding member of the Video Services Forum, and was a member of its Board of Directors from 1997 to 2001. He holds a BSEE from Clarkson University and an MBA from the University of Rochester.

Howard Greenfield is president of Go Associates, a global consulting firm that helps companies bring technology to the marketplace. He is a digital media and business development strategist as well as an accomplished columnist, widely published around the world. Howard has held senior management and consulting positions with Sun Microsystems, Informix Software, British Telecom and Apple Computer. He was the creator and leader of Sun's first Media Lab and completed graduate studies at Stanford University.

For the last two decades, Howard has been a successful technology developer, manager, educator and writer. In addition to front-line collaborative development ventures with Xerox PARC, Ericsson and the American Film Institute, he has held leadership roles involving early stage start-up companies and established corporations, three of which were subsequently acquired by Ariba, IBM and Microsoft.

Howard has presented and moderated at conferences throughout Silicon Valley, Europe, and Asia. He has served on government and cultural advisory boards that include the State of California, UK Trade & Invest, CNET and others. He also worked in the Apple Classroom of Tomorrow research and development, and is currently a board member of BlueVoice.org, an Internet media non-profit dedicated to protecting ocean life and habitats.

The authors welcome any comments, questions, or insights from readers. Please feel free to send e-mail to Wes at wes.simpson@gmail.com and Howard at howard@go-associates.com.

Introduction

> The world is changing very fast. Big will not beat small anymore. It will be the fast beating the slow.
>
> —Rupert Murdoch

The traditional business model for broadcasters, which has worked reasonably well for the past few decades, is starting to break down. Increasingly, consumers are demanding (and starting to receive) their video content in ways that were impractical even a few years ago. Consider the following:

- **Television Has Moved to the Web.** Viewers around the world tuned in to watch the 2006 FIFA World Cup in record numbers using their PCs and other Internet connected devices. InFront Sports reported more than 125 million downloads[1] from the fifaworldcup.com Web site of two-minute video clips with game summaries. While this number pales in comparison with the estimated 32 billion viewers of live broadcast coverage, the number of clip downloads increased by a huge factor between 2002 and 2006.

- **It's All Personal: PVR Timeshifting and Ad-Zapping.** The use of personal video recorders in the U.S. has skyrocketed over the past few years, with a variety of stand-alone solutions as well as those integrated into set top boxes from satellite and cable television providers. Worldwide sales in 2005 totaled 19 million units, and 11 percent of U.S. households have units.[2] Broadcast advertisers have grown increasingly upset by the practice of commercial skipping and the

---

1. fifaworldcup.yahoo.com/06/en/060713/1/8s8z.html

2. In-Stat, June 5, 2006,www.instat.com/press.asp?Sku=IN0603110ME&ID=1680

1 What is IP, and Why Use it for Video?

Nothing is really real unless it happens on television.
—Daniel J. Boorstin (American social historian and educator)

Before we try to answer this question, it's appropriate to consider what may be obvious – that video transport over *Internet Protocol* (IP) networks is not only here today, but is poised to become a dominant form of video service delivery for the next 20 years. As it unfolds, new media communications services that only the imagination can anticipate will arise along with it. We are at the dawn of an era that some hail as possibly the most fascinating phase in broadcasting history.

We will discuss the reasons more in this chapter, and the spread of IP will form a subtext throughout the rest of this book. However, there is little doubt that a large and vigorous market is developing though a confluence of improved compression, faster data links, more sophisticated software and evolving viewer habits. So, let's explore these trends, see how they impact network, technology, and business decisions today and, in the final chapter, see where these trends may lead us in the decades ahead.

Digital video is a precisely timed, continuous stream of constant bit rate information, which commonly works on networks where each signal is carried over a network that is purpose-built for video. In contrast, IP networks carry many different kinds of data from a huge variety of sources on a common channel, including e-mail, Web pages, instant messaging, *voice over IP* (VoIP) and many other types of data. With all of this data flowing together, the Internet is, at best, a loosely timed collection of information that is broken up into discrete packets. Clearly, IP and video don't make an ideal marriage of technologies.

In spite of this fundamental incompatibility, the market for IPTV and Internet Video is exploding. Why? Well, the answer to that question boils down to five basic arguments:

- Because broadband IP networks reach so many households in developed countries, video service providers can use these networks to launch video services without having to build their own networks.
- IP can simplify the task of launching new video services, such as interactive programming, *video on demand* (VOD) and targeted, viewer-specific advertising.
- The cost of IP networking continues to decline due to the massive volume of equipment produced each year and the existence of worldwide standards.
- IP networks can be found in every country in the world, and the number of users with high-speed Internet connections continues to grow at a rapid pace.
- IP is a perfect technology for many other applications, including data transactions (such as e-mail or banking), local area networking, file sharing, Web surfing and many others.

In this chapter, we will begin with a brief summary of the market trends for IPTV and Internet Video. We will then discuss in greater depth the five forces mentioned above that are driving the migration of video into IP, followed by a look at some issues that need to be addressed by any system trying to send video over an IP network. We'll conclude with a case study of a successful IPTV network installation.

The Corner Office View

"IPTV is a huge growth initiative. It's huge for us, it's huge for our partners. Count the number of TVs, and you don't have to get a lot of money per TV per year to start feeling kind of excited about the size of the opportunity."

— Steve Ballmer, CEO, Microsoft, speaking to analysts in July 2006[1]

1. IPTV International, Volume 2, Issue 2

The Internet Protocol

IP provides a mechanism for directing packet flows between devices connected on a network. IP is a common protocol used throughout the Internet and any of the millions of other networks that use IP. Without IP, chaos would reign because there would be no way for one device to send data specifically to another.

At its heart, IP is a standard method for formatting and addressing data packets in a large, multi-function network such as the Internet. A packet is a variable length unit of information (a collection of bytes) in a well-defined format that can be sent across an IP network. Typically, a message such as e-mail or a video signal will be broken up into multiple IP packets. IP can be used on many different network technologies, such as Ethernet LANs, long haul fiber optic and telephony networks, and wireless Wi-Fi links.

A number of different video services operate on IP networks, as we shall see in this book. Applications range all the way from low resolution, low frame rate applications like Webcams to high definition television and medical images. IP technology is incredibly widespread, and a huge variety of video technologies can use IP networks.

The Market for IP Video

So many different video applications can be implemented over IP networks that it can be hard to quantify them, and any attempt to do so will be quickly outdated. Nevertheless, a few facts and figures may be interesting:

- AT&T has begun rollout of Project Lightspeed, an IPTV network intended to be available to 19 million homes in the company's service area by the end of 2008. The company is planning an investment of $4.6 billion to make this a reality.[2]
- France Telecom had 421,000 ADSL Digital Television (IPTV) subscribers in France as of September 30, 2006. This is an increase of 38 percent over the 306,000 IPTV subscribers reported as of June 30, 2006.[3] Figure 1.1 shows the subscriber growth over two years, with a cumulative annual growth rate of more than 150 percent.

2. AT&T Corporate press release, May 8, 2006
3. France Telecom press releases, July 27 and October 26, 2006

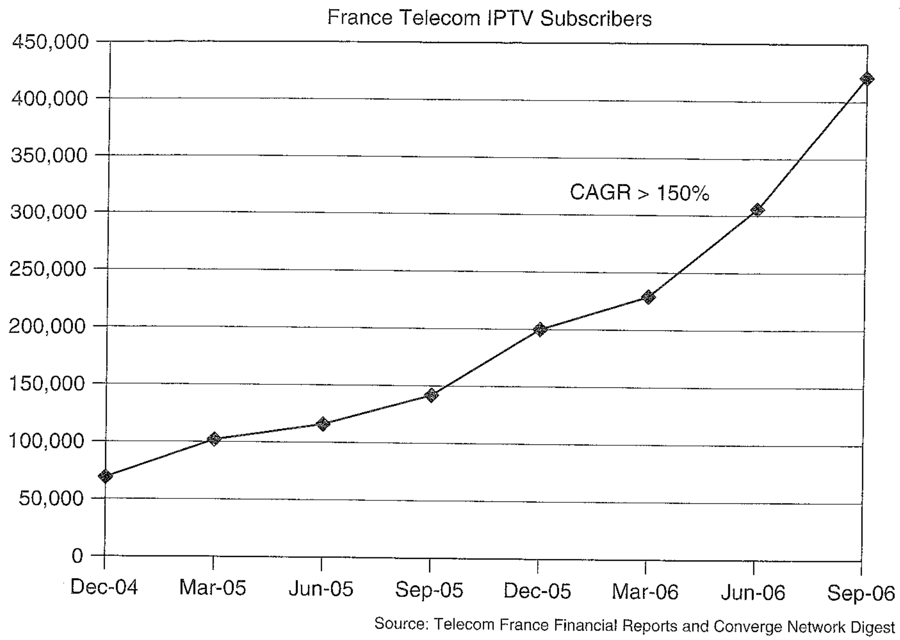

FIGURE 1.1 *France Telecom's IPTV Subscriber Growth 2004–2006*

- Google agreed to acquire YouTube, a leading Web site that allows users to view and upload original videos, for $1.65 billion in October 2006. At the time, YouTube was delivering more than 100 million video views every day and receiving 65,000 video uploads daily.[4]
- MRG, a market research firm, predicts that the number of global IPTV subscribers will grow from 8.0 million in 2006 to 50.7 million in 2010, a compound annual growth rate of 58 percent.[5] See the Reality Check section at the end of this chapter for more detailed information from this study.

The number of applications for video transport over IP networks is large and constantly growing. In this book, we will be focusing on IPTV and Internet Video, both of which are defined in detail in Chapter 2. However, there are a number of

4. Google/YouTube joint press release, October 9, 2006

5. IPTV Global Forecast—2006 to 2010, Semiannual IPTV Global Forecast, October 2006. Published by Multimedia Research Group, Inc., www.mrgco.com

other applications that use video transport over IP networks that deserve to be mentioned:

- Videoconferencing has moved out of the realm of dedicated rooms with specialized telecom data circuits into the world of desktop PCs interfacing with IP networks. These systems are characterized by low delay, low bit-rate systems that are suitable for "talking head" video but not much else.
- Webcams have become very popular, particularly for low cost, real-time communication. These systems typically run at very low frame rates (10 or fewer frames per second) and employ very inexpensive digital cameras. These systems can even be configured to work on dial-up connections, although this converts the "video" image into a series of still images with very low resolution.
- Many video surveillance devices intended for use in security applications have migrated to IP technology. There are a number of reasons for this transition, but one of the most compelling is the ability to use existing or easy-to-install Ethernet data cabling in place of coaxial video cables. In these networks, IP protocols and Ethernet cabling is simply used as a means to provide point-to-point connectivity between cameras, video recorders and displays.
- In the world of professional video production, IP networks are used for a variety of purposes (as is the case in many other modern businesses.) IP networks are used to provide connections between video editing workstations and file servers in a production studio. IP networks are used to transmit high quality video files and live feeds from remote venues back to production facilities. And IP networks are used to move video files containing raw footage, finished programming and advertisements to and from virtually every studio, post house and broadcaster in business today.

Not all of the above applications relate directly to the focus of this book, but all of them contribute to the rapidly growing, multi-billion dollar market that constitutes video over IP today.

Arguments in Favor of IP Video

There are a number of reasons companies and individuals decide to transport video signals over IP networks. Three of the most popular revolve around the flexibility of IP networks, their low cost and the incredible coverage that IP networks provide within an organization and around the world. Let's examine each of these arguments in more detail.

IP Network Flexibility

The number of applications of IP networks is truly staggering. The Internet Assigned Numbers Authority (IANA), which maintains the master address book for the Internet, has several thousand well-known and registered ports for different applications that use the IP protocol.[6] Some of the most common ones include port 80 for the Hypertext Transfer Protocol (http) that is used by the World Wide Web and ports 25 for Simple Mail Transfer Protocol (smtp) and 110 for Post Office Protocol – Version 3 (pop3) that are used for e-mail.

Counting the number of IP ports is just measuring the tip of the iceberg of IP applications, because many other programs use the protocols that have these port assignments. For example, there are literally dozens of different e-mail programs that work on a variety of different operating systems (Windows, Mac-OS, Linux, etc.) which all communicate by means of the ports defined for smtp and pop3.

Many different devices support IP. In addition to desktop and laptop PCs, servers and mainframes with a variety of different software operating systems can be configured to use IP. In addition, many other devices in the video world have Ethernet ports to allow all sorts of functions, ranging from simple status monitoring and control all the way up to HD video transport.

IP is also very flexible because it is not tied to a specific physical communication technology. IP links have been successfully established over a wide variety of different physical links. One very popular technology for IP transport is Ethernet, which is the dominant network technology in local area networks. Many other technologies can support IP, including dial-up modems, wireless links (such as Wi-Fi), and SONET and ATM telecom links. IP will even work across connections where several network technologies are combined, such as a wireless home access link that connects to a CATV system offering cable modem services, which in turn sends customer data to the Internet by means of a fiber optic backbone.

For broadcasters, this flexibility is important, but it is also a challenge. It is important because it gives broadcasters a choice among a large number of technologies and business models that can be used to deliver content in new formats. It is a challenge because it is impossible to choose a single solution for delivering video over IP networks that will suit all potential viewers.

6. A list of these ports was located at www.iana.org/assignments/port-numbers in August 2006

IP Cost Advantages

Economics is where things start to get interesting, because IP technology has a very low hardware cost. Virtually all new PCs and laptops come equipped with Ethernet ports. A quick scan of the Web shows that Gigabit Ethernet interface cards (which operate at 1,000 Mbps) can be purchased for as little as $15, and they get cheaper all the time. Other infrastructure, such as Ethernet switches, can be purchased for as little as $10 per port. For other networking technologies, such as ATM, SONET or even SDI video routers, costs are typically 10 to 100 times more expensive.

Basic IP software is also very inexpensive or often free. All major computer operating systems include built-in IP software "stacks" that support many different IP services without added cost to the user. This is important not only in commercial applications, but also for home users who might want to access Internet Video services while retrieving their e-mail. This is not to say that all IP video software is inexpensive—far from it. The software necessary to put together a functioning IPTV delivery platform that is scalable to hundreds of video channels and thousands of viewers can easily reach into the millions of dollars.

The low costs of IP networks are of great benefit to broadcasters for two reasons. First, low cost means that much of the network infrastructure needed to connect a video source to a viewer has already been purchased and installed by potential viewers; that which hasn't can affordably be purchased by the broadcaster. Second, as viewer expectations for quality and availability of content grow, putting upward pressure on network bandwidths, broadcasters can safely assume that the IP networks will continue to expand in capacity (which has proven to be a safe assumption for every year over the past three decades.)

IP Ubiquity

IP networks are truly pervasive in the post-millennial world. Both Antarctica and Greenland have over 8,000 Internet hosts each; the United States has 195 million.[7] Private IP networks exist in hundreds of millions of homes and businesses around the world—IP is the default technology today when people want to connect two computers together in order to share a printer or an Internet connection. For the traveler, Internet connectivity is available in hotels, airports, coffee shops and via *3G* mobile phone data networks in many large cities around the globe.

7. From the CIA Factbook located at www.cia.gov/cia/publications/factbook/fields/2184.html in August 2006

High-speed data access lines are continuing to be installed at a rapid rate in most developed countries. In the U.S., data collected by the Federal Communications Commission's Wireline Competition Bureau show that by the end of 2005, close to 40 percent of the nation's 109 million households had high-speed access lines in service. This number has been growing by between 3 and 5 million homes every six months for the past three years and shows no sign of abating. Figure 1.2 shows the trend for the past five years.

For broadcasters, the global reach of the Internet is both good and bad. It's good in the sense that anyone in the world with a suitable network connection is part of the potential audience for the broadcaster. (For example, it is perfectly possible to see the local Doppler radar for Connecticut from a hotel room in Tokyo.) It's bad in the sense that the role of the local broadcaster can be fiscally undermined by the disintermediation capability of the Internet. (Viewers in a locality have no need to watch a Hollywood movie by way of their local broadcaster's Web site when they can just as easily get the content directly from the studio's film library.)

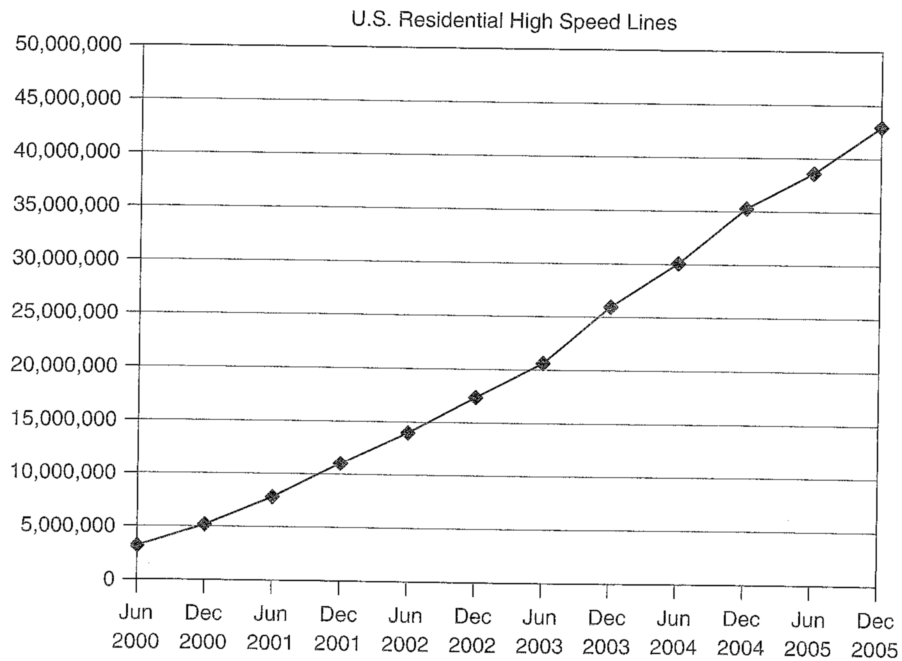

FIGURE 1.2 *U.S. Broadband Growth Trends, 2000–2005*[8]

8. From reports published by the FCC's Wireline Competition Bureau, www.fcc.gov/wcb/iatd/stats.html

Arguments Against IP Video

While there are powerful forces driving the use of IP networks for video transport, it is important to understand some of the potential drawbacks of this new technology. The first argument is primarily economic and revolves around the history of many things on the Internet being free of charge. The second is technical and centers on the difficulty of taking smooth, constant bit rate video signals and adapting them for transmission over IP networks. The third argument focuses on the dilemma of combining video signals that have very high demands for network resources on links that must carry other traffic and determining which uses will get priority. Let's look at each on of these in more detail.

Bad Attitudes About Payment

In some ways, the Internet is still dealing with some bad habits that were established in early days, when content was available for free to anyone who was able to connect. This spirit lives on today in a variety of ways, particularly in the widespread use of illegal file sharing for valuable music and video content.

Any broadcaster hoping to sell content over the Internet needs to be aware of these traditions and expectations and develop a policy to deal with them. One popular method is to deliver the content for free, but to include advertising on the Web site or inserted into the content itself. Another method is to charge fees on a subscription or pay-per-view basis. Both of these options will be discussed more in Chapter 3.

Obtaining legal access to content can also be a challenge. Many content owners have separate licensing terms for different forms of distribution. For example, a movie studio will have different terms and different licensees for each type of release: theatrical, pay-per-view, subscription television, DVD, commercial television and others. Creating a functional team inside a network-based carrier's organization to obtain these licenses can be an expensive and time-consuming process.

Jon Taplin, former CEO of Intertainer, now adjunct professor of communications at the University of Southern California, once related a pertinent anecdote about a conversation he had at a dinner party near the time of the first incarnation of Napster.[9] The conversation was with a father who had just surprised his teenage daughter with three music CDs that, through close family research, he knew she would love to have. Her response on receiving the gift was, "Dad! You bought these for me? Why didn't you tell me? We could have just downloaded them off the Internet!"

9. From www.go-associates.com/files/DigitalPiracy.pdf

As the public's perceptions of the Internet mature, and as content owners continue to win high-profile convictions against illegal file sharing, theft of services may become less of an issue. However, it is inevitable that some content will be stolen by some users some of the time. Also, as technology advances, the skills of encryption crackers will increase, forcing improvements to be made to encryption algorithms that modern *digital rights management* (DRM) are based on. It is incumbent upon content owners to ensure that all of their valuable content is protected with the latest available DRM technology.

Established Viewing Habits

Introducing new viewing habits into large populations of viewers can be difficult and time-consuming. Basic IPTV services closely mirror broadcast television and CATV, but so do viewer expectations about these services. Viewers will expect (and rightly so) that these basic services on IPTV offer a similar level of video quality and system performance to preexisting forms of delivery. More advanced services–such as video on demand and interactive programming–may require viewers to develop new patterns.

While these habits aren't impossible to change (look at the increasing penetration of digital video recorders), there can be a long and expensive learning curve. Plus, IP system operators must be conscious about competitors who create new services that can work over their existing broadcast and CATV facilities. New service providers need to take these factors into account, particularly when creating business plans for exciting new services that may be highly profitable but also require a change in viewing habits.

Network Jitters

Whenever continuous signals like video are cut up into packets for transport over an IP network, difficulties can arise. These mainly stem from the need for the packets to arrive in a timely manner, in the same order they were sent. When this doesn't happen, it places a tremendous burden on the receiving device to properly realign the packets while at the same time doing all of the processing necessary to produce the decoded video output. Some of these variations can be accommodated through the use of memory buffers in the receiving device, but these add delay to the end-to-end video connection.

Broadcasters need to realize that these potential impairments exist, and that there are methods for dealing with problems as they occur. Some of these solutions (such as increasing network bandwidth or replacing network routers) may not only be expensive but also impractical for networks that rely on the Internet.

A Matter of Priority

One of the great benefits of IP networks is the number of different applications that are supported. However, one of the burdens this flexibility places on network administrators is the need to prioritize the applications. Without a priority system, time-critical packets can run into delays caused by congestion of packets from many different flows, which can happen surprisingly often on IP networks.

Unfortunately, the existing mechanisms for handling priority packets on private networks are limited at best. These schemes are also useless on the public Internet, because priority routing is not implemented there. To understand why, consider the dilemma of deciding which packets in the public Internet should receive priority. Each user will, of course, think their packets are more important than those of other users. Without some type of global prioritizing or pricing scheme for different classes of packet service, efforts to add priority filtering to the Internet will be impossible.

Inside private networks, priority systems can be used, but there are still difficulties. Again, the problem arises from determining which types of signals will get priority. The argument for giving video signals priority over other signals is clear, because video signals do not perform well if their packets are delayed or dropped. However, video signals are one of the largest users of bandwidth on most networks and can take up a significant portion of the available capacity. Hence, the dilemma about choosing suitable priority levels can occur on almost any type of IP network.

Pioneer Syndrome

The old cliché about pioneers getting arrows in their backs can certainly be applied to IPTV pathfinders. Because of the complexity and relative immaturity of several of the technologies involved, innovators in IPTV can run into difficulties in a number of areas. One particular area of potential trouble is system integration, where technologies from different suppliers need to be knitted together into a seamless whole. A second area of potential trouble occurs when the network is scaled up to full deployment, where the number of subscribers moves from a few hundred relatively friendly customers to many thousands of paying customers. Large, technically proficient suppliers and system operators have run into problems like these in the past. Companies wishing to install IPTV systems need to recognize that much of this technology is relatively new and unproven and that problems can and will occur.

Reality Check

For this chapter's Reality Checks, we first explore an impressively large forecast that has been published for this market. While the amount of growth projected in this forecast is quite large, it certainly isn't the highest growth projection that we have seen. In the second reality check, we take a look at the IPTV market in France, which must be called a success by any measure.

Market Forecast

By any standard, the market for IPTV services has grown rapidly for the past few years, and industry observers expect that trend to continue. As can be clearly seen on the following charts, the pace of IPTV subscriber growth continues to accelerate. Figure 1.3 shows a forecast of the growth in the number of subscribers worldwide for IPTV from 2006 to 2010. Figure 1.4 shows a forecast of the growth in the amount of service revenue worldwide for IPTV from 2006 to 2010.

IPTV in France

At the IBC in Amsterdam in September 2006, IPTV was a hot topic, and for good reason: service providers were rapidly rolling out IPTV services to consumers all over the planet. Not every venture produces a winner, but there have been a number of successful deployments, and more are on the way. Graeme Packman, of Understanding & Solutions, a UK-based consulting firm, gave a very interesting presentation on IPTV during IBC and provided additional data used here.[10]

One country where IPTV seemed to be taking hold is in France. Between 2004 and 2006, more than 400,000 subscribers signed up for IPTV service from Orange (France Telecom). Alternative ISP Free provided an IPTV service with more than 80 channels in a package that included Internet access and telephony. About two-thirds of Free's 1.9 million broadband subscribers were eligible for this package. Other IPTV providers included alternative operator Neuf Cegetel, which had recently acquired AOL France, Telecom Italia subsidiary Alice and T-Online (Deutsche Telekom) subsidiary Club Internet.

France had an estimated 25 million television households, with approximately 3 million CATV subscribers and 4 million satellite subscribers (in addition to the

10. From a presentation entitled "IPTV—Overview and Keys to Success," September 10, 2006, at IBC, Amsterdam, and subsequent interviews. For more information, please visit www.uands.com

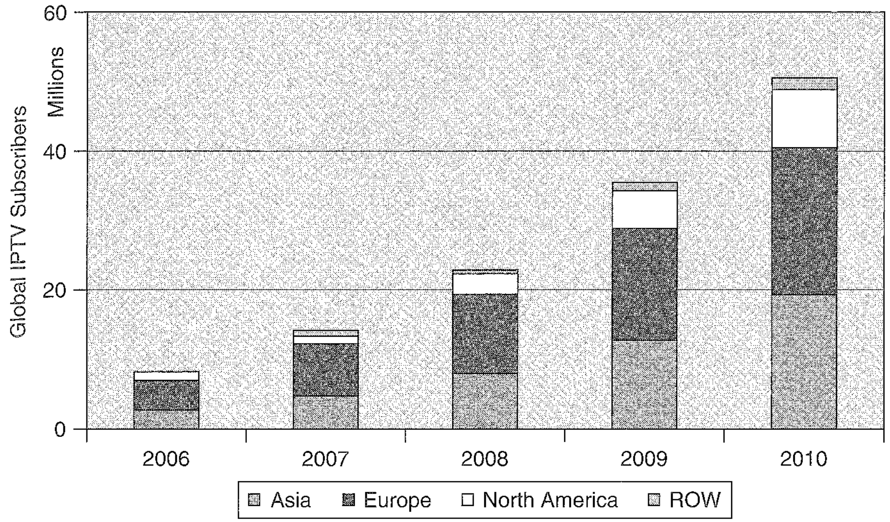

FIGURE 1.3 *IPTV Subscriber Growth Forecast 2006–2010.*
Source: © MRG Inc. 2006

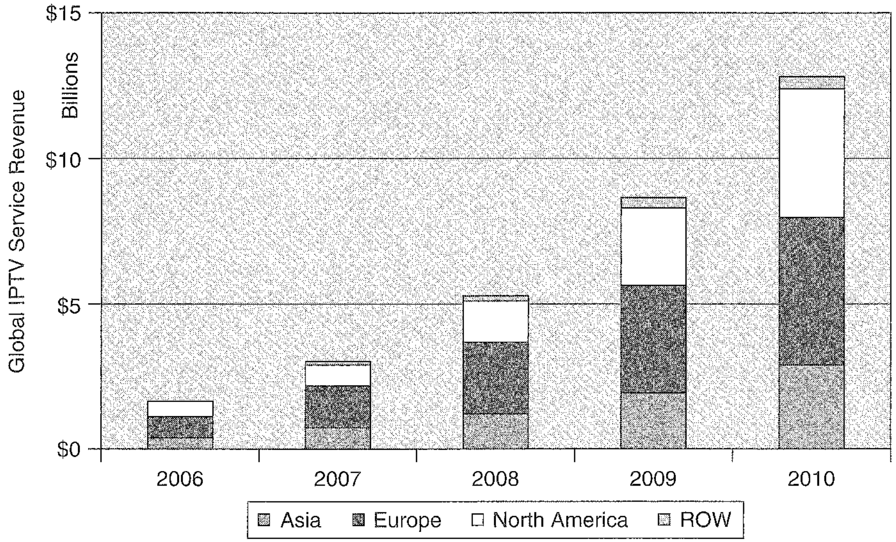

FIGURE 1.4 *IPTV Service Revenue Growth Forecast 2006–2010.*
Source: © MRG Inc. 2006

[11] Multimedia Research Group, Inc., publishes market analyses of new technologies for the communications industries and provides market intelligence and strategy consulting for its client companies.

1.6 million subscribers with IPTV service available). According to Point-Topic, another UK consultancy,[11] France had 11.7 million broadband subscribers as of June 2006, so there were a significant number of potential IPTV subscribers.

The success of IPTV in France occurred for a number of reasons, some of which were specific to the French market and some that may also have been true for other locations:

- **Pricing.** Due to a very competitive market, the prices for IPTV services were very low. Orange/France Telecom's basic IPTV service with more than 40 channels cost 16 Euros per month. Free's basic triple-play package—which included high speed ADSL2+ Internet access, free voice calls to fixed lines in more than 20 countries and IPTV—cost 30 Euros per month. At this low price, many Free customers were happy purchasing the package just to get Internet and telephone service and didn't utilize the television services. Incumbent Orange started to bundle its basic IPTV service, which includes more than 30 channels, free of charge with some of its broadband access offerings.
- **Weak competition.** As mentioned above, the main alternatives to IPTV were CATV and satellite, both of which achieved penetration far below levels in other countries. In the case of CATV, up to 2005 there were several cable operators who had not converted the analog base to digital as rapidly as in the UK, and most of these systems were without VOD capability. In the case of satellite TV, penetration was hurt by strict local planning rules that make it impossible for many potential subscribers to mount antennas on their homes. As a result, for many potential viewers, IPTV was possibly the only way to get digital TV services.
- **Wide range of content.** The channel offerings of the two largest IPTV suppliers were quite extensive. In addition to channels from all over France, both services offered basic-tier international programming from a number of other countries in Europe and the Middle East. In addition, Orange/France Telecom offered more than 200 premium channels. Both operators also partnered with media group Canal+ to offer premium content.
- **New services (HD and VOD).** While not as important as the reasons mentioned above, both high definition (HD) content and VOD services may have acted to drive subscribers to IPTV. The HD broadcast market in France was much less developed than the U.S. market at the time. IPTV service providers were positioning themselves to capture HD business by deploying HD-capable *set top boxes* (STBs) early-on. In France, VOD services were also not common, and IPTV providers were, in practicality, the first providers to offer VOD.

11. Data supplied by private correspondence with Point-Topic www.point-topic.com

Other countries in Europe offered a different picture for IPTV. For example, the UK, a country with roughly the same number of television households as France, had twice as many digital satellite subscribers (more than 7 million). NTL/Telewest operated CATV systems that passed half the homes in the UK and had 3.3 million subscribers. Overall, the penetration of digital TV services in the UK was almost 70 percent of viewers, a much higher ratio than in France or many other countries in Europe. As a result of these and other factors, the penetration of IPTV in the UK was much lower – only 30,000 subscribers as of 2005, according to an article in *The Register*. UK levels were expected to stay below levels in France for several years following 2006.

Summary

By now, it should be clear that IPTV is a force to be reckoned with today and for the foreseeable future, as powerful market drivers push companies and consumers to adopt this technology. Even though there are a number of issues that must be addressed before IPTV can reach its full potential, these issues are surmountable and are not very different in scope or magnitude from the difficulties that face any new technology.

In this chapter, we covered the basic motivations for using IP networks to deliver video services, including the flexibility, ubiquity and cost advantages that have persuaded many carriers to begin offering these services. We took a look at the market trends that are driving the rapid growth in this market. We then examined several factors pushing the spread of this technology. We concluded with a look at some issues that work against IPTV—although none of these appear to be anything more than the teething pains of a new technology.

2 IPTV versus Internet Video

This is definitely the Wild West in some ways; it's in the very early stages, and people are still learning.

—Adam Berrey, VP of marketing and strategy, Brightcove, in *The Washington Post*

Both IPTV and Internet Video use IP technology for video delivery, but that's where the similarities end. IPTV has similarities to traditional CATV, satellite and broadcast television, where continuous channels of programming are delivered to consumers for viewing on traditional television sets. In contrast, Internet Video delivers discrete pieces of content selected by individual viewers for viewing on a display connected to a personal computer. In terms of the range of content and amount of control, IPTV is like listening to music from a radio broadcast, whereas Internet Video is like listening to music on a personal MP3 player.

Both technologies have a role to play in video delivery. In Chapter 3, we will discuss ways that either IPTV or Internet Video can be used to create successful video delivery businesses. Many broadcasters will find themselves offering programming by means of one or both of these technologies; they are not mutually exclusive. Both forms of delivery can be useful for reaching different markets—or even a single group of consumers—who may want to view content in different ways at different times of the day. Broadcasters should become familiar with both IPTV and Internet Video technologies in order to position themselves to benefit as both markets mature.

This chapter is made up of two sections. In the first section, we will discuss the principal characteristics of an IPTV system. In the second section, we will discuss the different characteristics of an Internet Video System. At the end of the chapter, we will summarize the main differences in a table. In the Reality Check, we'll see how, even now, the differences between these two categories are starting to melt away.

The Corner Office View

Let's start with what IPTV is not. Specifically, it is not TV that is broadcast over the Internet. While the "IP" in its name stands for Internet Protocol, that doesn't mean people will log onto their favorite Web page to access television programming. The IP refers to a method of sending information over a secure, tightly managed network that results in a superior entertainment experience.

In particular, IPTV allows the service provider to deliver only those channels that the consumer wants at any given time—unlike traditional television broadcasting, where every channel is delivered to every home on the network. For the first time, it will be economical to deliver a college basketball game to everyone who wants to see it, for example, rather than just a particular local community.

— Mike Quigley, president and chief operating officer of Alcatel, writing in *Business Week*, May 20, 2005

Characteristics of IPTV

IPTV is primarily used to offer services that duplicate or exceed the features and functions of a CATV or direct broadcast satellite system by means of an IP network. Service providers who wish to deliver multiple consumer services over a single network often choose IP technology because it can provide voice and high-speed data access in addition to IPTV on a single platform. In a typical system, a private, high-speed IP network is used to continuously deliver video programming to hundreds or thousands of viewers simultaneously.

The typical IPTV network shown in Figure 2.1 is separated into three physical locations: the Video Serving Office (VSO), the Local End Office (LEO) and the viewer's home. The VSO is responsible for gathering video from a variety of sources and converting the signals into IP video streams. The LEO is responsible for combining video, data and voice signals into a form that can be transmitted over a network to the home. In this example, *Digital Subscriber Loop* (DSL) technology is being used, so the LEO contains a *DSL Access Multiplexer* (DSLAM) to format the signals. Inside the home, the incoming signal is split and reformatted for a number of purposes, including telephone service, high-speed data service and video that is fed to a television by way of an IPTV *set top box* (STB).

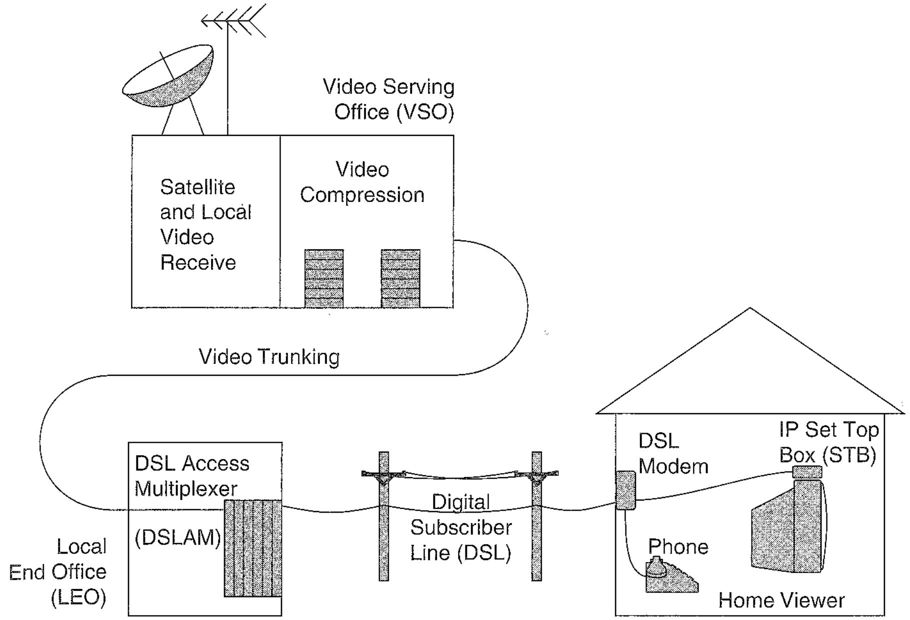

FIGURE 2.1 *Typical IPTV Network*

Many types of technology can be used to deliver IPTV service to the home, including DSL, fiber optics, wireless, CATV and even broadband over power lines. Regardless of the delivery technology, the basic characteristics of an IPTV network are quite similar, which we will now discuss in more detail.

Continuous Content Streams

IPTV is designed to send streams of video programming to each viewer. These streams are continuous—each viewer can select the stream they want to view, but they must join the stream in-progress. This process is functionally identical to the programming delivered by local broadcasters, CATV companies and satellite providers—the viewer is able to select the channel to be viewed, but not the content of the channels. This contrasts with Internet Video, where viewers generally select each piece of content they wish to view and play it in whatever order they want.

In most cases, the programming provided over IPTV systems is not created or owned by the IPTV provider. Instead, this programming is obtained from normal broadcast television sources, including broadcasters that may be located in the same city as the IPTV system. Broadcasters typically don't need to do anything special to their

content to prepare it for broadcast on an IPTV network—the process of compressing the video and formatting it into IP packets is usually done by the IPTV network provider.

There is one significant exception to the practice of delivering continuous streams of programming to an IPTV viewer. Most IPTV systems also offer on-demand content, where viewers can select videos that are stored on a server and played out upon request. These videos can be from a wide variety of sources and may be offered for free or for additional cost to the viewer. With true on-demand content, viewers can control the playout of the video to start, stop, rewind and fast-forward through the content. As service providers expand their server capacities, more and more content will become available on-demand.

Multiple Channels

The content that is delivered over an IPTV network is produced by a range of broadcast networks and delivered simultaneously to a large number of viewers. When viewers watch this programming, they will see regularly scheduled news and entertainment from network such as NBC, BBC and TF1; live or recorded sports from companies such as ESPN or Premier; 24-hour news reports from CNN, Al Jazeera and others; and a variety of specialized programming such as music video channels, movie channels, children's channels and home shopping channels.

IPTV networks are well-suited to deliver live programming such as sports or award shows to many viewers at the same time. Hardware inside the network is capable of making copies of the continuous content streams and delivering them to hundreds or thousands of homes simultaneously.

Viewers typically choose which channel they want to watch on their television by interacting with the IPTV STB. This can by done by simply entering the desired channel number on a remote control keypad or by making a selection from an *Electronic Program Guide* (EPG). An EPG can be as simple as a "barker" channel that passively scrolls though all of the current channel choices, or it can be interactive, enabling the viewer to navigate through a list of choices.

Once the viewer has chosen a channel, the STB must connect to the IP stream that contains the appropriate video data and use this data to create a video signal that is sent to the viewer's television. In cases where this data is already present at the input to the STB, the switch can be accomplished merely by changing to the desired data stream. Otherwise, the STB must signal the DSLAM (or other IP switching device further upstream) to deliver the new data to the STB. This is particularly common on networks with limited bandwidth connections to each home, such as DSL networks.

Uniform Content Format

Most IPTV systems use only one (or possibly two) video encoding formats for each type of content. The choices can typically range from MPEG–2 or MPEG–4 to VC–1 (which began life as Windows Media 9), but IPTV providers will typically choose one format for all video signals. This greatly simplifies the overall management of the IPTV system, allowing for a uniform system design and easing the burden on technicians maintaining the system. This also simplifies the STB design by eliminating the need to support multiple video decompression engines.

Any content that arrives at the IPTV provider that is not in the correct format must be converted. There are two main methods to do this. The first involves taking the incoming video feed and decompressing it to a baseband digital video signal before recompressing it using the desired compression system. The second is a process called *transcoding*, where the signal remains in a compressed state but is processed and reformatted into the new format.

Most IPTV providers also convert all of the incoming content into a common bit rate, usually one value for SD and a second for HD. This greatly simplifies the process of channel changing and overall bandwidth management; one fixed-bandwidth stream replaces another stream of the same bandwidth when a viewer switches channels. The process of changing the bit rate of video stream is called *transrating*.

Private Network Delivery

In order to deliver continuous channels of content to thousands of viewers in a repeatable manner, an IPTV network must be carefully provisioned and controlled. This task is daunting on a private network where all of the video content and other network traffic can be controlled. This task would be impossible on the Internet.

Playing a continuous video stream is a constant race against time. The video source signal must be received, compressed (usually) and converted into IP packets that must be delivered to every viewer's STB just when they are needed to create the video signal. If the packets arrive too early, they must be stored in the STB until they are needed. If the packets arrive too late, then the video signal playout can be interrupted. Some of these variations can be smoothed out using a memory buffer inside the STB, but that step adds delay in the end-to-end delivery path and can slow channel changing.

To keep the streams moving smoothly, the IPTV network must be managed to ensure that the IP connections to each STB are not overcrowded with packets. Overcrowding can be disastrous in an IPTV network, because it can affect all of the

packet streams, causing delays or even packet deletions that will surely affect the quality of the delivered video. On a private network, this can be avoided with careful engineering and by ensuring that each of the packet sources and destinations is controlled to prevent more packets from entering the network than can be delivered. In a public network that contains packet sources and destinations that can't be controlled by the IPTV provider, there is no mechanism to prevent overcrowding.

Viewed on Consumer Televisions via Set Top Boxes

Standard consumer television sets, until recently, have been very dumb devices when it comes to intelligently managing content. There is no mechanism to store video signals—any valid input is immediately displayed to the viewer. For most consumers, the television is located far away from the nearest PC, and many consumer PCs simply aren't up to the task of delivering high quality, full-screen, full-resolution video to the viewer. This is where the specialized hardware and software of an STB come into play.

The role of an STB is extremely important for an IPTV network. At a minimum, it must receive an incoming IP video stream, reassemble the data packets in the correct order, decode the video signal and produce an output that can be fed to a television (or projector) for display. It normally serves as the terminus for the IPTV network, so it must be able to receive commands from the user's remote control and send them into the network for action. It may also need some built-in intelligence to be able to generate text or other display used to communicate with the viewer, for functions like the EPG.

Internet Video

The viewer experiences and expectations for Internet Video are very different from IPTV. Most viewers have much lower expectations for Internet Video, particularly if they have ever tried to watch video over a dial-up connection. Of course, technology marches on, and the viewer experience continues to improve. Figure 2.2 shows a very simplified view of an Internet Video network.

This diagram contains two sections: production and distribution. In production, the video content is captured from a source, digitized, edited, labeled and bundled into a file that is placed on a server where it can be accessed. In distribution, a viewer uses an Internet-connected PC to search for content, connect to the server, acquire rights to view the content, and then either download a video file or request a video stream of the content for viewing on their PC using specialized multimedia viewing software.

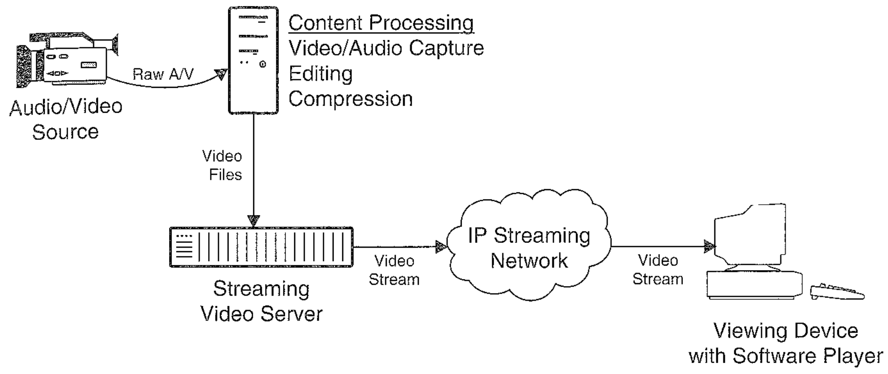

FIGURE 2.2 *Typical Internet Video Network*

A viewer using their PC or other device initiates a typical viewing session. First, the viewer must identify where the content is located on the Internet. For example, a user might have received an e-mail from a friend with a link to a Web site containing the video. When the viewer clicks on the link, the browser on their PC connects to the appropriate Web server. Typically, the Web server then displays a screen that gives some information about the video (such as a description and the clip's duration). The viewer then may be asked to click on a link embedded in that page, which begins the video playing process. One important step that happens at this time is an exchange of information between the server and the browser software on the PC that tells the browser to run a plug-in or stand-alone application called a *media viewer*. The media viewer will properly decode the incoming video data and convert it into an image that can be displayed. If the proper media viewer software isn't installed on the PC, the user will be prompted to install it by downloading the software from a suitable source. Then, as the video file is delivered, the viewer can watch the content.

Discrete Content Elements

Instead of continuous channels of highly produced programming, most Internet Video content is available for each viewer to select exactly what they want to watch at whatever time is convenient. Many of the video files that are available for viewing or downloading are relatively short—five minutes or less. Certainly, longer duration files are available, but they tend to be more limited in number, particularly considering the cost of server and network bandwidth needed to deliver these streams over the Internet.

Not all Internet Video is discrete content elements—there are some real-time streaming broadcasts available. For example, NASA TV offers some live video content each day from the International Space Station, as well as live coverage of major events

like shuttle launches and space walks (visit www.nasa.gov/multimedia/nasatv). In between, educational, news and other programming are provided. For-profit real-time Internet Video channels are also becoming a reality, as the number of viewers with high-bandwidth Internet connections reaches a level that is attractive for subscription or advertising-based services. (See the discussion of MobiTV in the Reality Check.)

Millions of Content Offerings

Any quick search of some of the more popular lists of video content on the Internet will show that there are well over a million different video files available for viewing, with thousands more being added each day. These can range from professionally produced music videos and movie previews to crude home videos and other amateur content. A great deal of content is available for free viewing; other files require purchase to view. Some sites allow the content to be downloaded for later playback; other sites only allow viewers to watch the content while they are connected to the site.

Locating a specific piece of content for viewing can be a challenge with Internet Video. Many viewers find content by following links on Web pages that direct them to video content sites. Others use the listings of popular titles on these Web sites. Still other viewers find the videos to watch using general-purpose search engines (such as Google) or site-specific search engines provided on some of the popular video Web sites. Unlike IPTV, there is no master EPG for the Internet—there's simply too much new content being added each day for this to be practical.

Multiple Content Formats

There are a wide variety of formats that can be used for video files, and virtually all of them have found their way onto the Internet. There are many choices, including various camera formats (such as DV), the MPEG family (1, 2 or 4), JPEG (basic or 2000), player-specific formats (Windows Media, QuickTime, Real Networks, etc.), and a variety of computer file formats (such as AVI and Flash). Consumers who view a significant amount of Internet Video content often end up with a collection of video players loaded onto their machines to handle the various video file formats.

For content providers, this variety can present a dilemma. If the provider chooses only to support a single video format, then any consumer who wishes to watch the content must already have the appropriate viewer software installed on their PC or find a way to get the proper viewer (most of which are distributed for free). If, on the other hand, the provider chooses to support multiple formats, then they assume the burden of producing and managing content in several different formats.

In addition to the choice of video compression technology, content providers must choose the screen resolutions they will support. Low resolutions offer small file sizes that are easier to download over low-bandwidth network connections but also create small images for viewing. Higher resolutions offer increased picture quality but can require a long time to download or a high-bandwidth connection for live streaming.

Delivered over the Internet

One big strength of Internet Video is that it can be delivered to any viewer with a connection to the Internet. Of course, high-bandwidth connections are easier to use and deliver quicker results, but even consumers with low-speed dial-up connections can download video files if they are patient enough.

Because video sites can be accessed from around the globe, the potential audience for any video can be very large, particularly if there is a good mechanism in place to inform consumers about the content that is available.

Use of the Internet also means that content providers don't need to build network facilities to all of their viewers, resulting in a significant cost savings. Unfortunately, this means that the network must be shared with a host of other applications that consume bandwidth. Also, there is no means for video content to be given higher priority than other types of traffic, which can dramatically increase the difficulty of delivering high-quality, high-bandwidth content in real-time to viewers, as is commonly done on IPTV systems.

Viewed on Consumer PCs

A reasonably powerful PC is capable of running the viewer software required to decompress and display most compressed video formats. Performance can sometimes be improved through the use of graphics accelerator cards or additional memory that is added to the system. In some cases, viewers will watch the content on the display screen of the PC itself; in other cases, the video will be displayed on a television set that is connected to a video output port of the PC.

Other consumer video playback devices have begun to enter the market for Internet Video content. One of the most popular portable video viewers is the Apple Video iPod, which features a screen resolution of 320 x 240 pixels. Most of these portable devices have a limited range of video file types that they will support, so it is essential for the consumer to select only those content files that are compatible with their device's capabilities.

Which Is Best?

In the preceding two sections, we discussed the principal differences between IPTV and Internet Video that we will discuss again in subsequent chapters. Table 2.1 summarizes the key points.

Now that these differences have been explained, the question may arise "How do I choose between them?" For many broadcasters, no choice may be necessary—the broadcaster may simply chose to offer content to viewers using both technologies at the same time.

- In the case of IPTV networks, there is no real difference to a broadcaster between having a signal carried on a digital CATV or a digital satellite network versus carriage on an IPTV network. In all three cases, broadcasters negotiate a contract with the network provider, and content can be supplied in almost any form that is convenient—over the air, as a digital video feed over a telephone company supplied circuit, as fiber optic connection or whatever format suits both parties. No matter what format is chosen, the IPTV network provider will most likely need to perform some sort of processing on the delivered signal to make it compatible with their network. This can include compressing the signal, changing compression format or many other changes that the broadcaster won't be able to control. Any or all of these tasks will need to be performed by the IPTV provider, just as they need to be performed by digital CATV or satellite providers.
- In the case of Internet Video networks, broadcasters will probably be heavily involved in managing which content will be offered to viewers and how it will be offered to viewers. In many cases, this content will be delivered to viewers by means of a Web site that is owned and operated by the broadcaster themselves. However, this will only be suitable for programming where the broadcasters own the appropriate rights. (This will not be that case in many circumstances for programming that is produced by independent production companies or that comes from national network feeds.) One visible result of the ownership limitation in the U.S. are local broadcaster Web sites. These sites heavily feature video clips from local news and weather programs that are produced by the local broadcaster, but they do not include other programming that is purchased from third parties.

	IPTV	INTERNET VIDEO
Nature of Content	Continuous streams of content	Discrete content segments
Content Selection	Hundreds of programming "channels"	Millions of content files
Content Format	One or two formats selected by provider	Dozens of formats with multiple players
Delivery Networks	Private IP network	Public Internet
Viewing Device	Consumer TV via STB	Consumer PC display or portable device

TABLE 2.1 *Key Differences Between IPTV and Internet Video*

Many broadcasters will find that their programming is carried in both ways—as linear feeds over CATV, IPTV and satellite systems, and as discrete content elements over Internet Video services. For popular prime time programming, most local broadcasters won't have the rights to host this content on their local Web sites. Instead, these programs may be available from the Web site of a national broadcast network. The question of who pays for this content will be something that we will take up in the next chapter.

Reality Check

For this chapter's Reality Check, we will discuss a relatively new service that combines some of the attributes of both Internet Video and IPTV delivery mechanisms. This example shows how these categories are already starting to overlap.

MobiTV – Blurring the Lines

An innovative service has been launched to provide standard television network programming to viewers via several different user devices. The service is named MobiTV because of the substantial deployment for mobile telephone users, with more than 1 million reported users in October 2006.[1]

MobiTV has introduced service into several different markets:

- Wireless network suppliers who have chosen a group of phones that can be configured to accept the MobiTV broadcast. For this to work, selected phones can be downloaded with special software that enable the phone to locate the desired data stream so the user can select the content to be viewed.

1. MobiTV press release, October 11, 2006

- Certain brands of smart telephones (such as Treo and Palm) have the ability to tune to MobiTV on any wireless network. These devices still require proper configuration and a data service from the wireless carrier. In fact, many carriers recommend that their users purchase an unlimited wireless data service to avoid excessive data service charges that might be incurred by viewing video over the networks.
- PC users with broadband connections, either through wired broadband connections such as DSL or cable modems or through wireless connections such as Wi-Fi, can subscribe to yet another service. One provider of this service, AT&T, is marketing this version of MobiTV under the brand name of "AT&T Broadband TV."

The mobile/smart telephone versions require a monthly subscription fee for the programming on the order of $10 per month as of this writing in addition to a wireless data plan. The PC version has a fee on the order of $20 per month; PC users must supply their own broadband network connections to the Internet.

AT&T Broadband TV is a hybrid of both IPTV and Internet Video. Here are the ways that the service is like IPTV:

- The content is provided in a linear broadcast, with no fast-forward, rewind or pause capability.
- Some channels have commercials; others do not.
- User interactivity is limited to choosing between different television channels.
- Channel change speeds are on the order of 1 to 10 seconds, perhaps somewhat slower than some IPTV installations, but quicker than most Internet Video applications.
- No noticeable buffering time is required when a channel is selected.

Here are the ways that AT&T Broadband TV is like Internet Video:

- Viewing is done using a standard PC running Windows software and the Adobe Flash player. No television tuner card is required in the PC.
- Viewers supply their own Internet connection.
- Video resolution depends on connection speed, with some video significantly below SD resolution.
- There is a substantial delay on at least some live television channels—we measured some at more than one minute.

As of this writing, MobiTV has raised $125 million in venture capital financing.[2] Investors included companies such as Adobe Systems, who supply the Flash software used by MobiTV, and Hearst Corporation, a large media company with television stations, newspapers, Internet and other media outlets. Clearly, some large companies are interested in participating as this market evolves.

There is no single, universal definition of what is IPTV and what is Internet Video. What's important is to remember that whenever IPTV comes up in a conversation, one should be careful to qualify what the speaker is talking about before making any conclusions.

Summary

This chapter focused on the differences between IPTV and Internet Video, terms that are often used in very similar contexts by experts. In this book, we will talk about IPTV as a video service that offers multiple channels of programming distributed on a real-time basis to viewers who typically use an STB to watch the content on a television or other display device. We'll talk about Internet Video that consists of thousands or millions of discrete content elements (files) that are viewed on a monitor for a PC.

These differences are important, because they affect the viewer's ability to control when and where specific content is viewed. As we move into the future, these differences will become somewhat less important, as IPTV providers offer more and more content on demand, and as Internet Video providers offer more linear and long-form programming.

2. From GigaOmniMedia, Inc. Web site article, gigaom.com/2006/11/01/mobitv-adobe-hearst/, November 1, 2006

3 Business Models

Information technology and business are becoming inextricably interwoven. I don't think anybody can talk meaningfully about one without the talking about the other.
—Bill Gates

Regardless of the technology, the key to success in delivering video services to consumers is a profitable business model. A wide variety of models are being tested in the market today for delivering video content over IP networks. Many different plans for user fees are being tried, ranging from completely free service to services that charge for each viewing of each piece of content. In the long run, it is likely that a few selected models will dominate, but for now, it is prudent to get an understanding of the many different models that are being used.

This chapter is divided into two main sections. In the first section, we will look at business models that are being used primarily for IPTV networks. In the second section, we will look at models that are often used for Internet Video businesses.

The lines can be blurry between these two groups, but here is the key point to remember: IPTV providers generally need to pay for installing and operating the network that delivers the services in addition to any costs for content, whereas most of the costs of Internet Video services relate to content acquisition and preparation. Of course, there are a number of other costs that we will discuss, but network costs can be major portion of the overall system costs.

The Corner Office View

For the ultimate example of an incumbent telecoms firm moving into TV, you have to visit Hong Kong. When PCCW, the local phone company, launched a TV-over-broadband service in September 2003, everyone laughed; it had tried similar

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ventures twice before, in 1996 and 2000, and had failed on both occasions. But its new service, Now Broadband TV, proved a success. Today it has more than 40 percent of the market and is on course to displace the local cable operator as the main provider of pay-TV in Hong Kong.

Moreover, last year PCCW became one of the first incumbent operators worldwide to arrest the decline in fixed-line subscribers. This is the kind of success that other telecoms firms dream of: a new service that not only stops line loss, but beats the cable companies at their own game and brings in new revenue. Better still, the service is expected to become profitable by the end of the year. No wonder that "just about every phone company in the world" has come to visit PCCW, says Alexander Arena, the firm's finance chief. PCCW is now advising telecoms firms in several countries about how to emulate its successful roll-out of IPTV.

—From "Tuning into the Future?",
The Economist, October 12, 2006

IPTV

As we discussed in Chapter 2, for now, IPTV networks primarily deliver multiple streams of continuous content over private networks to viewers who watch the content on normal television sets. While this sounds simple, a significant amount of technology needs to be installed and managed to provide these services. Table 3.1 summarizes the key cost elements of an IPTV system.

Table 3.2 gives the monthly programming costs for several popular television networks in the U.S. Note that these costs are paid by the IPTV system provider to the content owners; part of the business plan for the IPTV network is devising a way to recoup these costs from viewers.

In addition to the costs in Tables 3.1 and 3.2, other recurring costs must be covered. These include marketing, customer support and network maintenance. These costs can be hard to quantify before an IPTV system is deployed, but they can have a significant impact on the overall profitability of a system.

The following sections describe some of the business models that can be used for IPTV systems.

COST ELEMENT	COST BASIS	DESCRIPTION
Video Content	Recurring fee per month per viewer	Paid to content suppliers, such as broadcast networks
Delivery Network	Fixed, up front	Cost of IP network, part common equipment, part per-subscriber
STB	Fixed per subscriber	Often rented, sometimes purchased by consumers
Digital Head End	Fixed, up front	Receives video signals, converts into proper IP format
Content Servers	Fixed, scales with capacity	Used for on-demand and advertising
EPG	Recurring, scales with number of channels and subscribers	May be produced locally by IPTV provider or acquired from service bureau

TABLE 3.1 *IPTV System Cost Elements*

NETWORK	FEE PER SUBSCRIBER PER MONTH (2006)
ESPN	$2.91
Fox Sports	$1.67
TNT	$0.89
USA	$0.47
CNN	$0.44
Nickelodeon	$0.41
TBS	$0.39
FX	$0.36
MTV	$0.29
ESPN2	$0.24

TABLE 3.2 *Programming Cost Examples; Source: Kagan Research, LLC, a division of JupiterKagan, Inc.; used with permission*

Subscription

Subscription services are one of the most common methods used for funding IPTV systems. In this system, viewers sign up for a package of video services (channels) and pay a flat monthly fee. Subscribers are then allowed to watch as much or as little of any of the channels that are included in their subscription package.

Often, these services come in different tiers, with basic services (such as re-broadcasts of local over-the-air (OTA) programming) being the least expensive and premium sports or movie channels being the most expensive. Service providers try to group the channels into these tiers to maximize the number of subscribers at each level while minimizing the costs of the programming. This arrangement is similar to the pricing schemes used by many CATV and satellite providers; hence it is normally well-accepted in the marketplace.

For example, a basic tier of services may have several local OTA network feeds (which may have little or no programming costs to the IPTV provider), some news and weather channels, shopping channels, and other local content. A more expensive tier of services may include a variety of national entertainment, sports and music channels, including channels such as those listed in Table 3.2. This tier could easily be priced at 100 to 200 percent premium over the basic tier. Even more expensive tiers could be provided which include more variety, such as advertising-free channels or specialized sports channels.

Á là Carte Channels

This is similar in concept to subscription, except that each viewer is allowed to select exactly the channels they want to view, so he or she does not pay for the undesired channels. As above, the subscriber receives a monthly bill from the service provider, but only for the specific channels that have been chosen. The service provider in turn uses the revenue to pay content providers.

Within traditional CATV and satellite providers, á là carte channels have not seen widespread deployment. For IPTV providers, there are two advantages to this approach. First, since each channel that a subscriber is viewing must be individually sent from the IPTV network to the viewer's STB, it is technically less difficult to deliver only a specific group of channels to each subscriber. Second, IPTV providers may capitalize on subscribers' desires to pay only for those channels they wish to view; and á là carte channel selection option could be used as a service differentiator and market entry strategy.

Local Advertising

Local advertising involves inserting advertisements from merchants that might only appeal to local residents into network feeds before they are distributed to viewers. The technology for dong this is well established—many national content providers include special indicators in their programming feeds that tell the local providers when to insert their local ads. These indications, called *avails*, are provided by the content owners under the terms of contracts with the local service providers. In some cases, a local service provider may earn enough revenue from the local ads to partially or completely pay for the cost of the programming.

Many CATV providers have already designed their networks to take advantage of this important source of revenue. For IPTV providers, much of the technology is already available. Specialized servers collect advertisements from a variety of sources, and these servers can monitor multiple video channels simultaneously to locate avails. When one appears, the content from the server simply replaces the content of the programming feed.

The appeal of local advertisements is not limited to local businesses. Companies with global brands may wish to tie their advertisements to items of local interest, such as soft drink companies targeting fans of local sports teams. The challenge for a local service provider is to effectively market their selection of avails to the advertisers that will value them the highest.

Video on Demand

The idea of allowing viewers to watch any programming they desire whenever they want to watch it is not new. But, as technology advances and costs come down, *video on demand* (VOD) becomes more and more attractive to service providers.

The basic concept of VOD is based on video programming that is stored and then delivered to a viewer when it is requested. This storage can take the form of a centralized server that is equipped to send programming simultaneously to a hundreds of viewers, or it can take the form of more distributed storage throughout the network. At the limit, individual storage devices for each viewer can be located in individual STBs.

Various forms of VOD have been tried over the years, and most of them still exist in one form or another. Table 3.3 lists the most popular types of VOD services.

One of the big controversies surrounding PVR service (described in table 3.3) is the role of advertising in recorded content. Advertisers have two main concerns:

- Ad skipping, where viewers fast-forward through ads. This capability is often listed as the motivation for many consumer PVR purchases.

TYPE	DESCRIPTION
True Video on Demand (VOD)	This is the purest form of VOD, where each viewer receives an individual video stream that they have complete control over. Viewers are allowed to start, stop, pause, rewind and fast-forward the content. Viewers typically pay a fee for each title viewed; the charges are either debited from a pre-paid account or included on a monthly bill.
Near Video on Demand (NVOD)	Similar to true VOD without the individual video stream control capabilities. One common form of NVOD is sometimes called staggercasting, in which multiple copies of a program are played starting at five-minute intervals, thereby limiting any individual viewer to no more than a five-minute wait before his or her program begins to play.
Subscription Video on Demand (SVOD)	Same delivery technology and viewer control as VOD with a different payment system. In SVOD, subscribers pay a fixed monthly fee for unlimited access to a library of titles. In many systems, the library is updated monthly.
Free Video on Demand (FVOD)	A variation on VOD where payment is eliminated. In most systems, this content is restricted to long-form advertisements, how-to guides and other low-cost content.
Everything on Demand (EOD)	For some technology visionaries, this is the ultimate form of video delivery system, where all programming is available to all viewers at all times.
Personal Video Recorders (PVRs)	These devices take incoming video programming, compress it, and record it to a hard disk that is typically located either in an STB or a standalone device. Viewers then control the PVR to play back content, including pause, fast-forward and rewind capabilities. Also called *timeshifting*, viewers normally program the PVRs to record specific programs at specific times. One of the pioneers of this technology is a company called *TiVo*.
Network Personal Video Recorders (NPVRs)	Offers similar functionality to PVRs, but recording is performed inside the service provider's network, rather than in the viewer's location. Some content owners contend that this technology is so similar in capability to true VOD that it needs to be licensed as such.
Pay Per View (PPV)	This precursor technology to VOD is primarily used to deliver live paid programming, such as concerts or sporting events.

TABLE 3.3 *Types of Video on Demand Service*

- Ad timeliness, where viewers watch programs at times far removed from their original broadcast date. This is a big concern for some advertisers who have their ad campaigns targeted for specific time windows, such as promotional ads for a movie that is being released to theaters the following day.

Service providers have a limited amount of control over content that has been recorded by a viewer on their own device for later playback. They have only a slight bit more control over PVRs that are embedded in a STB supplied by the service provider—at least they can ensure that the DRM function is working to protect any copyrighted content while it is on disk. Providers actually have the potential to influence viewers who use a networked PVR, where the video recordings are actually stored on the service providers' own video servers.

Network PVRs have exciting potential to make advertisers much happier than with other PVR technologies. Why? Well, consider what happens in a normal PVR scenario with an advertisement. The machine faithfully records the commercials along with the program content and gives the user the ability to fast-forward through any parts of the program or advertisements at their whim. For example, say the viewer recorded a program on December 20 and decides to watch the program on December 29. As you could imagine, the program contained a number of ads that pertained to special last-minute shopping opportunities for Christmas. Unfortunately, when the viewer watches the program, the sales are over and the ads are completely worthless to both the viewer and the advertiser. Now, consider the same scenario with a networked PVR and some advanced technology in the server. With this technology, the service provider is able to replace the commercials that were in the original program with ones that are timely and relevant whenever the viewer watches the content. In this example, the ads might be for something great to do on New Year's Eve, which the viewer might actually be willing to watch, and an advertiser might be willing to pay for.

All that's needed to make this a reality is some pretty serious software inside the VOD server and some kind of legal framework to govern the "bumping" of one commercial by another. The industry isn't quite there yet, but this technology is certain to be available in the not too distant future.

Interactive TV

When viewers are given the opportunity to interact with broadcast content, the result is called *interactive TV* (iTV). This can take many forms, ranging from the simple press

of a button to more elaborate menu schemes. Here are a few common applications for iTV:

- Camera angle selection, where the viewer can chose one or more different camera angles of live sporting events
- Voting/opinion polling, where the outcome of a television event is determined by a vote of the audience
- Ad response, where viewers can request more information about a product or service being advertised

The key requirement for iTV is a *return path*, where user actions are sent to the service provider. Particularly in satellite applications, this can be difficult to construct, requiring connection of modem internal to an STB to the subscriber's telephone line. In contrast, in IPTV networks, the return path is already present, allowing for simple integration of iTV.

Triple/Quadruple Play

Triple play refers to multiple services being delivered by a single service provider, typically voice (telephony), data (Internet access) and television services. *Quadruple play* adds mobile telephony to the mix. Service providers typically offer discounts to customers who buy more than one service, which has proven to be a successful marketing ploy. The value proposition is that consumers benefit not only from lower prices but also the convenience of a single bill to pay (although the value of the latter is debatable).

From a service provider perspective, triple play services offer the combined cash flow from three separate services that can be used to pay for a common network that is capable of delivering all of them (such as networks based on IP technology). Of course, there are costs associated with installing the extra equipment needed to provide all three services, but these items can be paid for with moderate market penetration.

Certainly triple play has been the beautiful face that launched a thousand networking ventures. Carriers that traditionally had separate spheres of influence (for example, video versus telephony) are now rushing to deploy networks that can support all three aspects of the triple play. And these forays have been met with some success—a number of telephone companies acknowledged in 2006 (and some even earlier) that pricing and revenue for basic subscriber telephony services are in decline, partially due to the combined effects of VoIP technology and mobile telephones.

Internet Video via IPTV – The Walled Garden

IPTV providers have a dilemma. On one hand, they want to be the sole (or at least very dominant) supplier of video content to their subscribers, which is one of the best ways of securing continuous subscription revenue flows. On the other hand, there is a huge amount of content available on the Internet, and there will certainly be pressure from subscribers to have easy access to this content. To resolve this dilemma, some IPTV providers have resorted to a concept called a *walled garden*.

A walled garden can almost be thought of as a protected copy of some portions of the Internet, or possibly a set of content offerings that have nothing to do with the Internet. It can also be thought of as a heavily censored and filtered view of the Internet. Either way, only a small fraction of all the content available on the Web is included in the garden.

Service providers see several advantages for using walled gardens. First of all, the wall can prevent viewers from accessing content that may not be technically compatible with the network equipment or content that possibly contains harmful viruses, worms or Trojan horses. Second, the wall can help increase the amount of revenue that service providers derive from their content, in the form of advertising revenue or payments for on-demand content. Third, the wall prevents viewer access to content that may compete with what the service provider offers or content that may not be suitable for some groups of viewers, such as children.

The concept of a walled garden is not new. AOL tried to provide a walled garden for all their subscribers in the early 1990s. For a while, this model worked, with a variety of custom content available only to AOL subscribers. After time, this model broke down as users started to demand access to sections of the Web that were not inside the wall. In addition, the cost of creating and preparing content to reside within the walled garden became very expensive, even for a large company like AOL with millions of subscribers. As the decade wore on, AOL eventually switched to allow subscribers to have more open access to the Internet.

Internet Video

Internet Video delivery systems use the Internet as a means to deliver programming to viewers. As a result, the business models for this technology are significantly different from the business models that are used with IPTV systems. At the risk of completely abusing an analogy, there is no wall around this garden.

COST ELEMENT	COST BASIS	DESCRIPTION
Video Servers	Fixed, scales with number of streams provided	An adequate number of servers must be available to deliver streams to all of the simultaneous viewers of the content
Video Content	Often paid as a percentage of the revenue earned, if not free	Paid to content owners, such as performing artists and producers
Internet Access Bandwidth	Fixed, scales with number of streams provided	Fees paid to ISPs to supply high-bandwidth connections

TABLE 3.4 *Internet Video System Cost Elements*

Table 3.4 summarizes the major cost elements for an Internet Video service provider.

Subscription-based pricing is much less common in Internet Video than in IPTV. This is most likely due to the common perception that entertainment video is better suited to viewing on a television set than on a computer display (and sofas are typically more comfortable places to sit). In addition, most Internet Video delivery services are unable to offer anywhere near the video quality of a purpose-built television delivery service when both screen resolution and freedom from service interruptions are considered.

Some common elements are shared by both technologies. Both can rely heavily on advertising; although in the case of IPTV the advertising revenues tend to go more to the content providers whereas in Internet Video most of the ad revenues are collected by the portal provider. Both architectures support a variety of VOD services. And both technologies have a wide variety of business models that have been used successfully.

The following sections describe some of the business models that can be used to operate Internet Video services.

Pay-per-View

Pay-per-view (PPV) is often used for high-value content such as Hollywood movies. In this model, the viewer purchases the right to view a specific piece of content over a specific time period (often 24 hours). The viewer is entitled to pause, fast-forward and rewind the content, but loses all rights after the viewing window expires. Typically, the license only covers a single viewing device.

Part of the reason for these tight viewing window restrictions is simple profit maximization, but another part is security. If a viewer somehow devised a method to enable multiple devices to view content, the resulting "cracked" file would only be useful for a short period because of the display time limit. Such technologies help limit the incentive to devise these illegal techniques.

Rights Purchase/Podcasting

Much of the content delivered over Internet Video systems is sold in the form of a permanent license, where the rights to store and view the content are delivered to the viewer for an unlimited time. Users are allowed to download the content onto their PCs or other viewing devices and play back as desired. Typically, there is a limit to the number of devices that can be used to play the content, to prevent viewers from reselling the content to other parties.

One somewhat contentious issue for providers is the concept of backup copies. Consumers want the right to make backups so they don't lose the rights to a valuable collection of content items as a result of a hard disk or other device failure. On the other hand, content owners fear that a liberal backup policy could result in widespread misuse of their valuable content.

Subscription

Some Internet Video content is sold by subscription. Two business models are often used:

- Live Video Access, where viewers pay a monthly fee in exchange for the rights to view live streaming video (such as sporting events).
- Video Library Access, where viewers pay a monthly fee to have access to a collection of content that can be played.

Subscription models work best when there is a collection of unique content and a group of viewers who are willing to pay. Examples include Major League Baseball in the U.S., news programming from a variety of countries in different languages and a variety of adult content. Financial success depends on controlling the costs of production (perhaps by sharing production costs with other television outlets, such as local television broadcast stations) and on establishing a subscriber base large enough to cover the system costs.

Advertising Supported

As with e-mail and Internet search portals, many Internet Video providers started out by offering free services to viewers. As the user base grows, it becomes economically feasible for the portal owners to sell advertising space, in the form of static ads displayed on the portal's Web page or as video advertisements played immediately before the viewer's selected content.

Revenues derived from advertising can be used in three interesting ways, aside from filling the pockets of entrepreneurs and venture capitalists. One way is to use the revenues to purchase more content from suppliers, either as an outright purchase or in the form of revenue sharing. Another way is to hire people and purchase equipment to create a larger-capacity and more user-friendly portal that will attract more viewers and increase ad revenues. The third way to spend the revenues is on marketing, thereby attempting to increase the number of viewers using the portal. These choices are not mutually exclusive—many providers will choose to do all three as a way of increasing the success of their Internet Video services.

Free and User-Contributed Content

Human creativity knows no limits. The fortuitous combination of low-cost, high-quality camcorders, animation software, audio recording/mixing software, synthesizers and professional-grade editing software that can run on PCs has created an immense pool of people who have the means to produce their own digital video clips and programs. Certainly a lot of the content that is produced is only beautiful in the eye of its creator, but enough inspiring, intriguing or amusing content is being produced to populate any number of Web sites with high-quality content.

One way for service providers to create revenue from this type of Web site is to charge users a fee to host their video content, to simplify sharing between friends and family members. As demonstrated by a number of photography sites that have done this, it can be tricky to create a profitable business.

Another way to fund a "free" video Web portal is to sell advertising space on the portal itself or to push advertisements to viewers before the content is played. This can provide enough revenue for the service provider to cover their costs, particularly for bandwidth and storage.

A third common way to fund a "free" video Web portal is to offer previews of video content that needs to be purchased. For example, many professionally produced music videos are available for sale. A number of Web sites have been created that provide free previews of these clips, along with links to sites where they can be purchased and downloaded. Other types of preview content are available for movies currently in theatrical release or on DVD. Web sites that feature these previews can be funded by commissions or other "click-through" accounting methods.

Reality Check

Clearly, the scale of investment required to install and operate an IPTV system requires some form of payment from viewers. In the following Reality Check, we will take a look at one local telecom supplier who has been able to successfully build and operate a fairly compelling IPTV delivery system.

Canby Telcom

Canby Telcom is an incumbent local exchange carrier located in Canby, Oregon, about 20 miles south of Portland.[1] The company has provided telephone service to local residents for more than 100 years. Currently, the company provides 11,000 telephone access lines to 8,600 customers.

The geography covered by Canby Telcom consists of a good deal of agricultural land. The company provides service over an area covering 84 square miles. A large number of Hispanic people have moved into the area to work on the flower and tree nurseries that are a common feature of the area.

In October 2004, Canby Telcom received approval for their business plan to deploy a full set of triple-play services to their customers. In addition to the voice services they traditionally supplied, the company decided to offer and broadband data IPTV service using DSL technology. The company began offering service to their first customers using this new system in October 2005.

Canby's basic offering includes voice, data and video service using ADSL2+ technology. Customers have a choice of 1.5, 3.0 or 6.0 Mbps data service in the downstream direction. For subscribers within 5,000 feet of a DSLAM, Canby is able to offer up to three simultaneous video streams. Customers between 5,000 and 8,000 feet from the DSLAM can be supplied with two simultaneous video streams.

1. Information on Canby Telcom provided by interviews with company management (Keith Galitz, President, et al) in November 2006 and through other published sources

System Construction

The Canby Telcom IPTV system was constructed using equipment and software from a number of different suppliers. This is the case with essentially all current IPTV deployments, because of the wide variety of different technologies involved. The following list indicates some of the key building blocks and their respective suppliers.

- Content Processors—Tut Systems Astria CP. These units are responsible for taking incoming programming from a variety of sources and converting it into the common compressed digital format that will be delivered to viewers.
- Remote Terminals (DSLAMs)—Calix C7 Multiservice Access Platform. These units sit inside Canby Telcom's facilities and generate the DSL signals that are sent to subscribers. They also receive upstream data back from the subscribers.
- DSL Modems—Best Data 542 Four Port Ethernet switch/router. These units receive the incoming DSL signals and separate the packets into up to four streams. Three streams can each be connected to one of the STBs, and one can be used to provide high-speed access for a PC.
- Middleware—Myrio. This software provides a number of functions, including supporting the channel change process and presenting information to viewers such as the EPG and the VOD selection menu.
- Encryption/DRM—Verimatrix. This software works in conjunction with the Myrio software to protect the digital content from being misappropriated by viewers or by third parties.
- STBs—Amino AmiNET 110. Small, powerful STB with Ethernet input. Supports Standard Definition MPEG–2 programming only.

Services Offered

Canby offers quite an impressive array of triple-play service options. Basic telephone service is available throughout the company's serving area. DSL service is available to 99.6 percent of the homes and businesses in the serving area. As of November 2006, IPTV service was available to 3,000 homes in the serving area.

DSL service is offered at three speeds—1.5, 3.0 and 6.0 Mbps downstream. Upstream speeds are up to 512 kbps. While there is a slight price difference between these two options, it is important to note that either option can be used in conjunction with IPTV service.

The IPTV service offers economy television, an enhanced package and five premium programming packages. As of November 2006, the economy tier had 19 channels and sold for $17.95 per month.

The enhanced package is sold as the "Essentials" package for $48.95 per month and includes the economy channels. This package includes more than 100 channels of content, much of which is traditionally delivered to CATV head ends around the country. More than ninety percent of Canby's IPTV subscribers have chosen the "Essentials" package.

Four of the five premium packages are movie channels, each with multiple channels for different content types and time zones. Each of these packages sells for $11.95 per month.

The fifth premium package is somewhat unique, because it includes only Spanish language channels. It includes several channels produced by U.S. programmers and live feeds from several television networks based in Mexico. This $6.95 per month service is popular with many of Canby's customers who have come from Mexico to work on the local agricultural businesses.

VOD is also up and running at Canby. As of November 2006, more than 800 titles were available for viewers to watch, with 43 percent of those available for viewing at no charge. Some of this latter content includes recordings that were made at live music concerts.

Investment

Canby Telcom was somewhat of an early mover in the IPTV market, due to the company's desire to roll out services beginning in 2005. This may have caused the cost of their system to be higher than what might be typical today for two reasons:

- MPEG–2 compression technology continues to decline in price as time passes, similar to other trends in the high technology field.
- Some of the technologies that Canby had to use were quite new and had not been fully integrated with the other technologies. As a result, the integration costs may have been higher than what would be experienced for a similar system today.

Even with these higher costs, Canby was able to install their entire IPTV digital head end for less than $2 million of invested capital. The primary cost elements that made up this total included:

- Digital head end, which includes the content processors and other signal receiving and processing functions, accounted for 70 to 75 percent of this total.

- VOD system, including the disk drives that actually store the content and the servers that create the IP packet streams that deliver the content to viewers, accounted for 20 to 25 percent of this total
- Other equipment, including the satellite receiver dishes and associated electronics, middleware servers and initial licenses, accounted for the balance of the investment.

Results

Due to a combination of good engineering, affordable pricing and relatively weak competition from the local CATV company, Canby Telcom has been able to achieve good take rates. As of November 2006, the company had 900 IPTV subscribers, out of a total of approximately 3,000 homes passed, for a take rate of 30 percent. What's more, 77 percent of the IPTV customers take the full triple play of video, voice and data from Canby, helping to prevent erosion in the basic telephony population, which had been a concern of Canby's management.

Summary

In this chapter, we discussed a variety of topics that relate to the business models that are being tried for both IPTV and Internet Video. Because these technologies and their applications are so new, it is difficult to determine which business models will be successful and which ones will not pan out. Only with time (and some large sums of money) will these answers start to emerge.

We began by looking at both the equipment costs and the programming costs for an IPTV system. Then, we examined some of the methods that can be used to get viewers to pay for these services, including subscriptions, local advertising and VOD. We then looked at several business models that have been used with Internet Video, including pay-per-view, podcasting, subscriptions and advertising supported. We also glanced at free video portals that have been primarily supported by investors with deep pockets who hope to devise a way to earn a return in the future. We concluded with an in-depth look at a real IPTV system that is meeting its financial goals ahead of plan.

4 Network Overviews

People [are not] abandoning television or going to the Internet or doing other things and taking away from television viewing activity. The pervasiveness of the medium is not being eroded.

—David Poltrack, Executive Vice President,
Research and Planning, CBS Television

IPTV and Internet Video systems can be very complex puzzles to put together. As any jigsaw enthusiast will say, it is hard to understand how each individual piece of technology fits into an integrated whole unless there is a way to look at the overall picture. In this chapter, we hope to provide this big picture view.

A wide variety of network architectures have been successfully used to deliver IPTV and Internet Video services. Describing all those variations is impractical in a single book, but it does make sense to look at typical network architectures for each delivery method. By understanding these reference models, readers will get a better understanding of all the elements that make up both types of video delivery systems.

Interestingly, in the IPTV section, we will spend most of our time describing hardware components, whereas in the Internet Video section, we will spend a lot of time discussing software. Why the difference? Because most IPTV networks have to be constructed from various hardware components to reach each of the subscribers, whereas Internet Video delivery takes place over links to the Internet that are purchased independently by each subscriber. In other words, IPTV service providers usually need to build a network to reach their viewers, whereas Internet Video service providers typically use existing networks.

The Corner Office View

"So why now?" asked Jeff Weber, SBC's vice president of product and planning for Project Lightspeed [at NAB 2005]. "I've already been asked this question a thousand times and it's already come up today: 'The telcos have been down this path before—what is it that makes you think that SBC can pull it off this time?'"

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5 IP—The Internet Protocol

The Internet is not just one thing, it's a collection of things—of numerous communications networks that all speak the same digital language.

—Jim Clark

IP is the most successful computer networking technology ever invented. A recent count shows almost 440 million host computers connected directly to the Internet.[1] Every new desktop or laptop computer produced today comes equipped with a networking connection that supports IP.

With a basic understanding of IP networking, our discussions about IP video will be much more valuable to you. It is not at all unusual for special network designs to be required in order to transport IPTV reliably. In this chapter, we will discuss the basics of IP transport, explain the key concept of a packet and show how IP fits into the overall scheme of data communications. We will then cover unicasting and multicasting, two key concepts in video networking.

The Corner Office View

The remarkable social impact and economic success of the Internet is in many ways directly attributable to the architectural characteristics that were part of its design. The Internet was designed with no gatekeepers over new content or services. The Internet is based on a layered, end-to-end model that allows people at each level of the network to innovate free of any central control. By placing intelligence at the edges

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1. From Internet Systems Consortium, Inc., www.isc.org. This number doesn't include the millions of computers that are connected within private networks and share an Internet connection

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rather than control in the middle of the network, the Internet has created a platform for innovation. This has led to an explosion of offerings—from VoIP to 802.11x Wi-Fi to blogging—that might never have evolved had central control of the network been required by design.

—Vinton Cerf, Chief Internet Evangelist, Google Inc., and co-inventor of TCP/IP[2]

A Simple Analogy

A very simple, limited analogy may be appropriate here. In some respects, an IP address is like a telephone number. If you know someone's telephone number, there is a pretty good chance you can pick up your phone and call him or her. It doesn't matter what country the person is in, as long as you dial correctly (adding country code when required), and it doesn't matter what kind of technology that person is using—mobile phone, cordless phone, fixed rotary or tone-dialed phone. Several different network voice technologies may be used to complete the circuit, including copper cable, fiber optics, microwave links, satellite links and other wireless technologies. However convoluted the route, the call goes through.

For data networks, an IP address provides the same function as a telephone number: it is a mechanism to uniquely identify different computers and to enable them to contact each other and exchange data over a huge variety of different network technologies.

Stretching the analogy a bit further, simply knowing someone's telephone number doesn't mean you're going to be able to communicate with him or her. A call might be placed when nobody is there to answer the phone. The phone might be engaged in another call and not available. The call might go through just fine, but if both speakers don't use a common language, communication won't occur. The same is true with IP networking—simply knowing another computer's IP address doesn't mean that two applications running on two different machines can communicate with each other.

2. Vinton Cerf letter to U.S. House of Representatives Committee on Energy and Commerce, November 8, 2005, googleblog.blogspot.com/2005/11/vint-cerf-speaks-out-on-net-neutrality.html

Of course, it is important to remember that IP networking and telephony are two very different technologies. Telephony is "connection-oriented," meaning that a specific circuit must be established between the sender and the receiver of information before any communication takes place (such as a voice conversation or a fax transmission). In a call, all the information flows over the same path. IP, on the other hand, is "connectionless," meaning that the information (such as data, voice or video) is broken up into specific IP subunits, called packets, prior to transmission. Each packet is free to take any available path from the sender to the receiver.

What Is a Packet?

An IP *packet* is a unique container for data. It consists of a string of data bytes that has a defined format, including a header and a block of information bytes. Each packet can be a different length (within limits), but once it is created, each packet has a constant length.

The header of each packet contains information about the packet. Most important is the destination address, which is the IP address of the destination for the packet. The header also includes the IP address of the source of the data, so two-way communication can be easily established between two devices. This also enables packets from different sources going to different destinations to share a single physical communications link. Devices at either end of the link (called *routers*) can sort the packets out and deliver them to different destinations based on the IP addresses in each packet's header.

The biggest strength of an IP network is that many different packets, all containing data from different applications, can share a single packet transport link. This permits the tremendous flexibility of an IP network—once a device does the hard work of converting a particular data stream into packets, the rest is easy, because the IP network will take care of delivering the packets to their destination. Once they are delivered, it is again the responsibility of an application to take the data out of the packets and put the data to work. This isn't a trivial process—the receiving application must deal with any IP network delivery errors.

How IP Fits In

IP provides a very useful mechanism to enable communications between computers. IP provides a uniform addressing scheme so computers on one network can communicate

with computers on a distant network. IP also provides a set of functions that make it easy for different types of applications (such as e-mail, Web browsing or video streaming) to work in parallel on a single computer. Plus, IP enables different types of computers (mainframes, PCs, Macs, Linux machines, etc.) to communicate with each other.

IP is very flexible because it is not tied to a specific physical communication method. IP links have been successfully established over a wide variety of different physical links. One very popular technology for IP transport is Ethernet, which is often used for local area networking. Many other technologies can support IP, including dial-up modems, wireless links (such as Wi-Fi), DSL, SONET and ATM telecom links. IP will even work across connections where several network technologies are combined, such as a wireless home access link that connects to a CATV system offering cable modem services or a DSL line, which in turn sends customer data to the Internet by means of a fiber optic backbone. This adaptability is one of the things that makes IP so widespread.

IP doesn't do everything. It depends on other software and hardware, and other software in turn depends on it. IP fits between the function of data transport performed by physical networks and the software applications that use IP to communicate with applications running on other devices. Figure 5.1 shows how IP fits between applications on the top of the networking hierarchy and physical communications on the bottom.

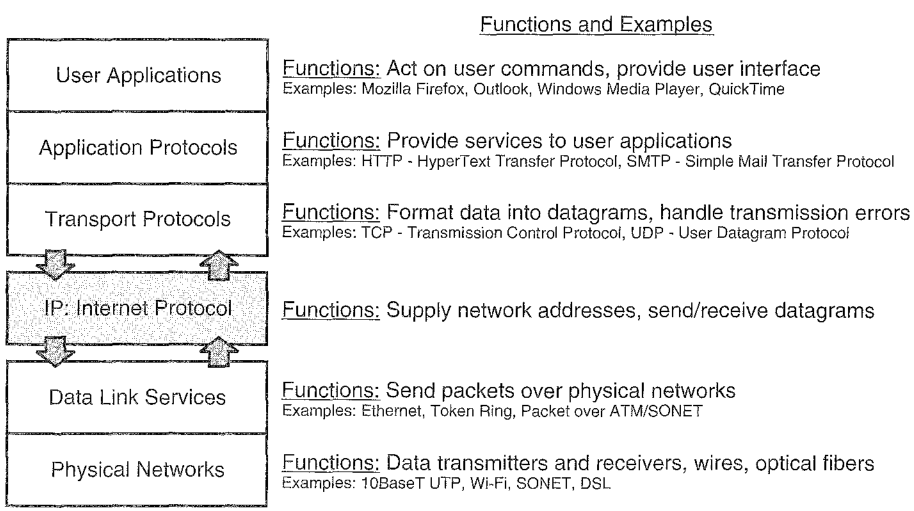

FIGURE 5.1 *How IP Fits Between Other Layers of Networking Protocols*

IP is not a user application or an application protocol. However, many user applications employ IP to accomplish their tasks, such as sending e-mail, playing a video or browsing the Web. These applications use application protocols such as the *HyperText Transfer Protocol* (HTTP) or Simple Mail Transfer Protocol (SMTP). These protocols provide services to applications. For example, one of the services provided by HTTP is a uniform method for giving the location of resources on the Internet, which goes by the abbreviation URL.

IP by itself is not even a reliable means of communications; it does not provide a mechanism to re-send data that might be lost or corrupted in transmission. Other protocols that employ IP are responsible for that. Using the telephone analogy again, IP can connect the telephone call, but it doesn't control what happens if, for example, the person being called isn't home, or if the call gets interrupted before the parties are finished talking. Those occurrences are the responsibility of the protocols that use IP for communication.

Types of IP Networks

Many different types of physical networks can be used to transport IP data. In this section, we'll review some of the most popular ones and describe where they are commonly used.

Ethernet

Ethernet is almost certainly the most widespread data communications network in the world. Robert Metcalfe and David Boggs invented the technology in the mid-1970s, and the growth since then has been exponential. Ethernet is used in local area networks to connect computers, printers, servers, IP routers and many other types of devices. There are three commonly used speeds for Ethernet connections—10 Mbps, 100 Mbps and 1 Gbps. The first two technologies are often called 10baseT and 100baseT, respectively, and the fastest of the three is often called GigE. Standards have also been defined for the next logical step in speed, called 10GigE, but today this interface technology is expensive and fairly rare.

Ethernet is a *Local Area Network* (LAN) technology. This means that it is not suitable for use in *Wide Area Networks* (WANs) or Metropolitan Area Networks (MANs). The reasons for this are that Ethernet has some fairly short distance limitations (2,000 meters in many instances) and cannot be too large for timing reasons.

Basic Ethernet cabling usually consists of special twisted pairs of conductors called CAT5 or CAT6, depending on the speed rating (the higher number rating is capable of faster speed). An Ethernet network can also be implemented over optical fibers; this is reasonably common for GigE links and very common for 10GigE links.

Ethernet networks are very common in modern office settings and are often used in home networks. Many networks that were originally set up to share a printer with a small group of PCs have expanded to cover hundreds of devices throughout a building. These networks will often contain a variety of servers and network interfaces, including Internet connections. Many home networks were originally installed for the sole purpose of enabling multiple PCs to share a single high-speed network connection.

Wireless Ethernet

Wireless Ethernet is becoming very popular for many applications, including connections to laptops and other portable devices. A couple of popular names for this technology are 802.11 (the number of the IEEE standard) and Wi-Fi.

Most Wi-Fi networks are configured with fixed central access points (AP) that provide a common node that connects to all the portable devices. Typically, the AP provides a connection to a high-speed network that supports Internet access or access to a corporate network.

Wireless transmissions can be affected by a number of different factors in the local environment, and data transmission speeds can change rapidly. As a result, systems will use automatic packet re-transmission to ensure that the data gets delivered. Unfortunately, this can cause the data transmission speed to fluctuate rapidly and without warning. This can make it extremely difficult to reliably send video information.

Wi-Fi is used inside many homes for connecting PCs to each other, printers and the Internet. The main advantages are portability and elimination of the need to string cables to every location in the home where a PC is going to be used. Wi-Fi hot spots (locations where one or more APs are located) are very common in locations visited often by frequent travelers. It is not used often for professional video networks because of the limited bandwidth and the highly variable delay.

Cable Modems

Many CATV companies have started providing a wide variety of services to customers in the hopes of capturing a larger portion of their customers' monthly telecommunications expenses. As a result, many customers have been extremely pleased with the reliable high-speed services offerings.

Cable modems work by taking digital data signals and converting them into high frequency signals that flow over CATV cabling, in place of some of the television content. The relevant standards for these signals are called DOCSIS, for Data Over Cable Service Interface Specification, developed by a consortium lead by CableLabs. Since data services are bi-directional, transmission must take place in both directions on the CATV cable. This might require some extra equipment or maintenance on existing CATV systems to make sure that the return paths from subscribers back to the head-end are working properly.

Cable modem termination system (CMTS) shelves are located at the CATV head-end. These provide high-speed data connectivity to hundreds or thousands of CATV subscribers. The output of the CMTS system is one or more RF signal that is combined with normal video signals that are distributed to all of the viewers in an area. At each broadband user's home, a cable modem is installed that tunes to the required frequency and selects the data addressed to that user's home. The data is converted into standard Ethernet format and delivered to the user's PC or other device (such as a home router or Wi-Fi access point.) On the return trip, the cable modem accepts data from the end-user device and transmits it back to the CMTS by way of an RF channel on the CATV return path.

Cable modems are quite popular in the U.S., with roughly equal numbers of cable modem and DSL broadband households. IPTV services can be delivered over cable modems. However, since CATV systems already have a video delivery system, they are not often used for IPTV, possibly except for some VOD services. Internet Video services are frequently delivered over cable modems. Outside the U.S., cable modems are less popular but are still used for a significant number of broadband households.

Digital Subscriber Lines

Digital Subscriber Lines (DSL) provide broadband data services over long twisted pair cables. They were developed to allow companies that had telephone lines installed to customer homes to offer high speed Internet connections without having to install a whole new CATV or fiber optic network.

Very special techniques are required to get high-speed digital data to move reliably over cables that were designed just to handle low-frequency voice signals. There are trade-offs between speed and distance—longer distances allow more subscribers to be served from a single office, but at lower speeds.

Special technologies have been developed to modulate the data onto the twisted pairs and to cancel any echoes that may occur during transmission. This technology

requires advanced digital signal processing, with very high performance chipsets that are undergoing constant improvement. As a result, new standards are constantly being developed.

DSL is used primarily in networks that already have twisted-pair networks installed. It makes little sense to use DSL technology in new construction areas, as there is not a tremendous cost premium for installing fiber optic systems in a completely new network build. Even major proponents of DSL such as AT&T are planning to install fiber in new developments.[3]

Fiber Optic IP Networks

Optical fibers have a number of advantages for high-speed data transport, and these benefits certainly apply to IP networks. These advantages include an extremely high data carrying capacity,[4] isolation from outside interference, long transmission distances (including undersea cables) and low cost per kilometer.

IP packets can be sent over optical fibers in a number of different ways. One popular method involves sending GigE and 10GigE signals directly over fiber. Another method involves mapping packets into SONET/SDH-compliant signals and transmitting those over an optical network. A third method involves sending IP packets over fibers in a format designed for fiber to the home transmission.

Both IPTV and Internet Video signals can be transmitted over optical fiber, and at some point, essentially all streams do pass over fiber between video sources and viewers. Fiber is often used for distributing broadcast television content on a national and international level, and it is virtually always used for long-distance Internet transport. Fiber is normally used to distribute content from VSOs to DSLAMs. Fiber can be used to deliver IP packets directly to consumers in both IPTV and Internet Video applications.

IP Addresses

IP addresses are easy to recognize due to their special format. This format is called "dotted decimal" and consists of a series of four numbers separated by periods (or

3. From a presentation at IBC on September 9, 2006, entitled "AT&T U-verse TV" by Paul Whitehead of AT&T

4. Nippon Telegraph and Telephone Corporation reported a speed of 14 Terabits per second on a single fiber in a September 29, 2006 press release (www.ntt.co.jp). This is equivalent to 14,000 Gigabit Ethernet links on a single fiber

dots). A dotted decimal number represents a 32-bit number, which is broken up into four 8-bit numbers. For example, 129.35.76.177 is the IP address for www.elsevier.com. Most folks who have configured their own home network or laptop connection have probably seen information in this form.

Of course, being human, we have a hard time remembering and typing all of those digits correctly (even when writing a book). So, the *Domain Name System* (DNS) was invented to make life easier. DNS provides a translation service for Web browsers and other software applications that takes easy-to-remember domain names (such as "elsevier.com") and translates them into IP addresses (such as 129.35.76.177).

IP addresses are key to the operation of an IP network. They form the unique identification that each device must have to be able to send and receive packets. On any network, each device must have a unique address; otherwise the network wouldn't be able to deliver packets properly. Private networks that contain several devices and one Internet connection can use private IP addresses inside the network while sharing a single public IP address for access to the Internet.

Key Parts of an IP Network

Many different types of equipment can be used to construct an IP network. Since purchasing, installing and operating these devices can represent a large portion of the cost of an IPTV or Internet Video system, it makes sense to describe some of the key system elements.

- Ethernet *hubs* and *switches* are used to physically move data packets from one device to another inside a physical location. Hubs have essentially no packet processing intelligence—they simply take any packets that come in on one port and transmit them out all the other ports of the hub. Switches are more intelligent—they can determine where each packet is going and send each packet out on the proper port. Switches are invaluable for connecting the hundreds of IP devices found in even a medium-sized corporation. Switches have a limited scope, however—they only pay attention to directly connected devices. Switches do not have the ability to look at a packet and figure out that in order to get to destination Z the packet needs to be sent first to devices X and Y. That is the function of an IP router.
- IP *routers* are the workhorses of an IP network. They are essential for delivering packets across a large network, because they are able to figure out a route for each packet. These routes can travel great distances through multiple devices over many different kinds of physical networks, such as wireless, fiber optic, twisted pair and DSL links. It is not uncommon for a router to manage several thousand

different packet routes, even though it may only be connected to a few dozen other devices. As a result of their flexibility and intelligence, IP routers can be quite expensive, particularly for ones that can handle large bandwidth loads, as is common in video networks.

- Web and data servers provide a wide variety of data sources for a broad spectrum of purposes. These servers need to support the IP protocol to operate on the Internet and the World Wide Web. Typically, these units are set up to respond to transactions that have been initiated by client devices, such as user PCs.
- Client devices cover a wide range of different technologies, form factors and uses. They can range from desktop PCs of many different vintages and capacities to an array of portable and even handheld units. These units are typically set up to run applications that users can invoke to accomplish specific tasks.

In a typical transaction over an IP network, a user at a PC types in a command to do something, such as read an e-mail or news article. This is accomplished by means of an application running on the user device, such as an e-mail application or a Web browser application. These applications provide the user interface that appears on the user device, including displays on the device screen and a mechanism for the user to point and click or type an instruction.

When the user's command is completed, the application software will typically create a command output by sending data through a protocol such as HTTP. Referring to Figure 5.2, this process can be visualized as a downward movement through the

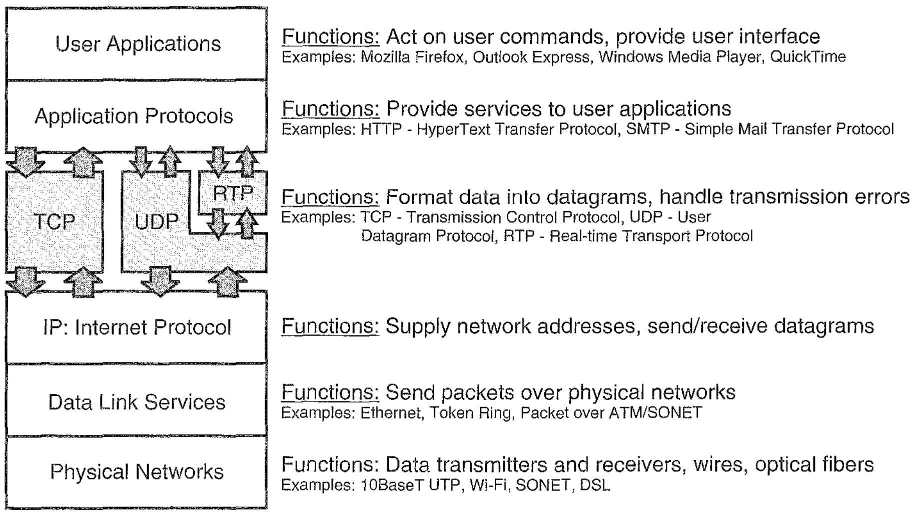

FIGURE 5.2 *Transport Protocol Hierarchy*

different protocol layers. The command created by HTTP is then passed on to a transport protocol such as TCP, where it is given addressing information and formatted into packets for handling by IP. The IP layer takes the packets and makes them suitable for transport over the actual data network such as Ethernet. Ethernet is then responsible for actually transmitting the packet data over a physical cable to another machine, where the process is reversed, i.e., the data is passed back up through the protocol stack on the receiving device. Eventually, the data from the user is delivered to an application on the receiving machine. At this point, the user's request can be responded to either automatically (as in the case of a Web server) or manually (as in the case of an e-mail).

When the response is ready, the process is reversed. In the responding machine, data is passed down through the various protocol layers and onto the physical connection back to the user's machine. The response is then passed back to the user's application, and the transaction is completed.

The real beauty of this way of handling messages is that each protocol layer has well-defined, specific responsibilities. This also makes it possible for one layer to change without having to rework all of the other software. Consider the introduction of wireless networking over the past 5 to 10 years. While it is true that various operating systems (such as Windows or Mac-OS) had to be rewritten to accommodate these changes, most user applications (such as Microsoft Outlook or Adobe Acrobat) did not. Similarly, new versions of applications can be released without having to change the basic underlying protocols.

Transport Protocols

Transport protocols are used to control the transmission of data packets in conjunction with IP. We will discuss three major protocols commonly used in transporting real-time video:

- *UDP* or *User Datagram Protocol*: This is one of the simplest and earliest of the IP protocols. UDP is often used for video and other very time-sensitive data. In UDP, the originating device can control how rapidly data from a stream will flow across the network. In other protocols (such as in TCP, covered next), the network can drastically affect how data transfer works. For video and other real-time streams, UDP is a logical choice for the transport protocol, since it does not add unneeded overhead to streams that already have built-in error correction functions. Because UDP does not require two-way communication, it can operate on one-way networks (such as satellite broadcasts). In addition,

UDP can be used in multicasting applications where one source feeds multiple destinations (covered in greater detail in the next section).

- *TCP* or *Transmission Control Protocol*: This is a well-established Internet protocol widely used for data transport. The vast majority of the devices that connect to the Internet are capable of supporting TCP over IP (or simply TCP/IP). TCP requires that a connection be set up between the data sender and the data receiver before any data transmission can take place. One of the essential features of TCP is its ability to handle transmission errors, particularly lost packets. TCP counts and keeps track of each byte of data that flows across a connection. The automatic flow control mechanism will slow down data transmission speeds when transmission errors occur. If this rate falls below the minimum rate needed by a video signal, then the video signal receiver will cease to operate properly.
- *RTP* or *Real-time Transport Protocol* (or Real Time Protocol, if you prefer) is intended for real-time multimedia applications, such as voice and video over the Internet. RTP was specifically designed to carry signals where time is of the essence. For example, in many real-time signals such as video, if the packet delivery rate falls below a critical threshold, it becomes impossible to form a useful output signal at the receiver. For these signals, packet loss is better tolerated than late delivery. RTP was created for these kinds of signals—to provide a set of functions that are useful for real-time video and audio transport over the Internet. Overall, RTP adds a lot of functionality on top of UDP without adding a lot of the unwanted functions of TCP. RTP also supports multicasting, which can be a much more efficient way to transport video over a network, as we will see in the next section.

In the networking hierarchy, all three protocols are considered to operate above the IP protocol, because they rely on IP's datagram transport services to actually move data to another computer. Figure 5.2 shows how UDP, TCP and RTP fit into the networking hierarchy. Note that RTP actually uses some of the functions of UDP; it operates on top of UDP.

Multicasting

Multicasting is a key concept for IP networking. However, there are two very different meanings of the word that can apply to the field of IPTV:

- In over-the-air digital television broadcasting, multicasting means delivering multiple video programs simultaneously over a single digital broadcast channel.

- In IP networking, multicasting means delivering a single stream to multiple viewers simultaneously.

Broadcast multicasting became feasible with the advent of terrestrial digital television. Within a standard digital channel (19.38 Mbps in the U.S.) it is possible to have multiple video channels, each occupying a portion of the total bandwidth. For example, ION Media Networks (formerly Paxson) has more than 50 digital broadcast stations across the U.S.—each one is capable of delivering at least four different SD programs simultaneously using multicast technology.

In IP multicasting, a single video stream is sent simultaneously to multiple users. Through the use of special protocols, copies of the video stream are made inside the network for every recipient. All viewers of the multicast get the same signal at the same time.

Market penetration for both types of multicasting is limited. Broadcast station owners are just beginning to explore the types of broadcast multicast services that consumers will actually watch. Most of the IP networking equipment delivered over the past five or more years is capable of supporting IP multicasting, but it has been disabled out of fear of an excessive burden on networks. For example, IP multicasting is not currently enabled on the Internet, restricting the use of multicasting for IP video steaming to private networks. However, in newly constructed IPTV systems, multicasting is a key technology.

IP Unicasting

To get a better understanding of IP multicasting, it is helpful to compare it to the process of IP *unicasting*. In unicasting, each video stream is sent to exactly one recipient. If multiple recipients want the same video, the source must create a separate unicast stream for each recipient. These streams then flow all the way from the source to each destination over the IP network.

Each user who wants to view a video must make a request to the video source. The source needs to know the destination IP address of each user and must create a stream of packets addressed to each user. As the number of simultaneous viewers increases, the load on the source increases, since it must continuously create individual packets for each viewer. This can require a significant amount of processing power and also a network connection big enough to carry all the outbound packets. For example, if a video source were equipped to send 20 different users a video stream of 2.5 Mbps, it would need to have a network connection of at least 50 Mbps.

An important benefit of unicasting is that each viewer can get a custom-tailored video stream. This enables the video source to offer specialized features such as pause, rewind and fast-forward video. This is normally practical only with pre-recorded content but can be a popular feature with users.

Unicasting is the norm for Internet Video for two reasons. First, the Internet is not multicast-enabled, so it is not feasible to use multicasting.[5] Second, most Internet Video viewers expect to be able to control video streams (i.e., pause, rewind, fast-forward), and this is impossible with multicast streams.

IP Multicasting

In multicasting, a single video stream is sent simultaneously to multiple users. Through the use of special protocols, the network is directed to make copies of the video stream for every recipient. This process of copying occurs inside the network, rather than at the video source. Copies are made at each point in the network only where they are needed. Figure 5.3 shows the difference in the way data flows under unicasting and multicasting.

In multicasting, the burden of creating streams for each user shifts from the video source to the network. Inside the network, specialized protocols enable the network to recognize multicasted packets and send them to multiple destinations. This is accomplished by giving the multicast packets special addresses that are

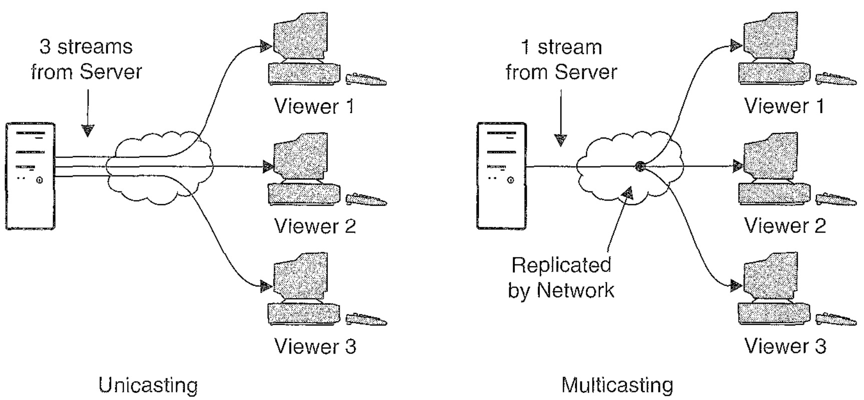

FIGURE 5.3 *Unicasting vs. Multicasting*

5. Alternatively, a streaming server could be used to handle the load of creating multiple packet streams

reserved for multicasting. There is also a special protocol for users that enables them to inform the network that they wish to join the multicast.

Keep in mind that multicasts operate in one direction only, just like an over-the-air broadcast. There is no built-in mechanism to collect data from each of the endpoints and send it back to the source (other than some network performance statistics like counts of lost packets). This means that any interactivity between the endpoints and the video source must be handled by some other mechanism.

Multicasting in IPTV

Multicasting is a key technology for IPTV because it enables a single source signal to be sent to multiple destinations. This can enable hundreds, or even thousands, of viewers to simultaneously watch a single television broadcast.

In an IPTV network (as described in Chapter 4), there are several points inside the distribution network from the SHE to the viewer where multicasting can be used to great effect.

From the SHE output, multicasting can be used to take a single live stream and distribute it to multiple VSOs. This saves the expense of constructing a high-bandwidth streaming server inside the SHE. This also greatly reduces the size of the network connection required at the output of the SHE.

When it comes to distributing broadcast television streams to viewers, multicasting is almost always used. This technology enables a viewer's STB to connect to a program feed simply by joining a multicast. However, where this happens is greatly dependent on the capabilities of the DSLAMs. Some DSLAMs are multicast-enabled, and others are not.

- When the DSLAMs are not multicast enabled, a unique video stream must be sent for each viewer all the way from the VSO to that viewer's STB. This requires a high bandwidth connection from the VSO to each DSLAM, with enough capacity to handle all of the active viewers simultaneously. This approach has the advantage of reducing the complexity (and therefore the cost) of the DSLAMs.
- When the DSLAMs are multicast enabled, the connection between the VSO and the DSLAM can be simplified, with only one copy of each broadcast channel needing to be sent. Requests to join and leave the multicast are received from STBs and processed inside the DSLAM; copies are made as necessary for each STB. While this approach increases the complexity of the DSLAM, it does significantly reduce the amount of bandwidth needed to feed signals from the VSO to each DSLAM.

Issues with Multicasting

Multicasting is not enabled on all IP networks, because there are some noticeable drawbacks to the technology. These include network resource burdens, management complexity and unverified file transfer. Let's explore each of these in more detail.

As mentioned in previous sections, one drawback of multicasting is the additional burden that it places on the network, primarily routers. Routers are impacted in two main ways—processing the overhead packets containing multicast join and leave instructions, and processing the live streams. In most IPTV systems, broadcast channels (such as prime-time network TV) are broadcast using multicast technology. Each time a channel change takes place from one multicast stream to another, several messages must be processed, including instructions to stop delivering one stream to and to start delivering a new stream to a user's STB. In addition to this overhead processing, the IP router needs to be able to make a copy of every single multicast packet for every destination served by that router. In some cases, the copies will go to another router downstream toward the destination. In other cases, the copies will go directly to a STB. If a router has to serve hundreds or thousands of STBs, each with a multicast stream, this can require a lot of processing power.

Multicast networks can be complicated to manage. In the most popular multicasting protocol, there is a built-in mechanism to gather feedback from all of the distant endpoints. This protocol is carefully designed to minimize the amount of traffic coming back from the endpoints, with the tradeoff being that each endpoint reports less often as their number goes up. This can make it difficult to determine when several endpoints are having difficulty with a particular stream.

Bit-for-bit file copying using acknowledgments is not compatible with multicasting. Normally, when perfection is demanded (say in a million dollar financial transaction), the endpoints are designed to handshake with each other after each block of data is successfully delivered. Any mistakes require re-sending the damaged or missing packets. This is impractical for a multicast, since it is unlikely that all endpoints would always experience the same errors at the same time. Accordingly, there are other protocols (such as TCP) that can be used to transmit data when errors must be totally excluded.

Reality Check

In this chapter's Reality Check, we take a look at the immense growth of broadband services that has taken place over the past few years. While the growth rates have slowed in some countries as penetrations increase, millions of broadband lines are

still being installed each month around the world. All of these lines service potential customers for IPTV and Internet Video.

Broadband Network Growth

For IPTV and Internet Video to operate with any level of user satisfaction, a broadband network connection is essential. While it is technically possible for a dial-up user to view a video signal, the long delays needed to download even a short clip at very low resolution make dial-up impractical. So, to get a feel for the market for IPTV and Internet Video, we must restrict our focus to broadband users.

A good working definition of a broadband connection is one that offers more than 256 kbps of throughput. This is adequate for low resolution, low frame rate video in real time. It may also be enough for a user to download a short video clip from a Web site in a reasonable amount of time. This kind of speed simply cannot be achieved with a dial-up modem operating over an analog voice line.

There are many different ways to look at broadband network statistics. One way that makes sense is to look at the worldwide deployment of broadband links, since this comprises the total available market for IPTV and Internet Video services.

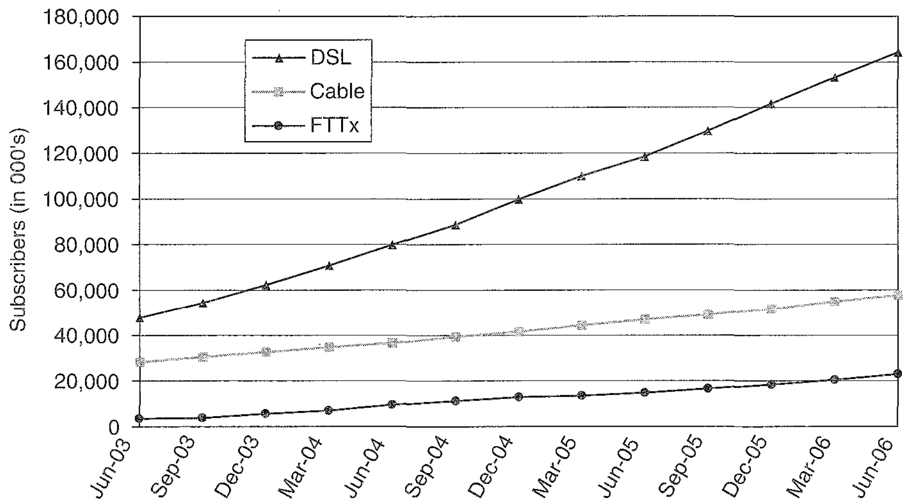

FIGURE 5.4 *Worldwide Broadband Growth by Technology © Point-Topic, Used with Permission*[6]

6. Vince Chook, "World Broadband Statistics Q2 2006" Point-Topic Ltd., www.point-topic.com/

Figure 5.4, from Point-Topic, shows the worldwide growth of broadband circuits from 2003 to 2006 in three different technologies: DSL, Cable modem, and *fiber to the node/fiber to the home* (FTTx on the diagram).

As this illustration shows, expansion has been quite rapid, growing from a total of 79.7 million lines at the end of Q2, 2003, to 247.2 million at the end of Q2, 2006. This calculates to a cumulative growth rate of just under 46 percent per year. On current trends, the worldwide penetration of broadband will reach 5 percent by the end of 2006, leaving a great deal of room for future growth. Compare this to 1.263 billion fixed line telephones in use and 2.168 billion mobile/cellular phones in use in 2005,[7] and it is easy to see the immense growth potential for broadband services.

Summary

IP has changed the world of data communications and impacts the physical world around us more all the time. As telecommuting, videoconferencing, virtual worlds and the increasing array of online video content reduce the need for travel for communication's sake, a range of possibilities open up. As the Internet continues to grow, most people will be able to learn about whatever they want from the comforts of their own homes. More and more devices are becoming IP enabled, from cell phones to refrigerators, and they will all end up connected somehow, over networks that are becoming IP-centric. The opportunities created will be enormous due to what IP helps make happen.

In this chapter, we began with a basic discussion of the properties of IP and looked at some of the roles that IP plays in the hierarchy of data communications. We then described some popular types of devices that support IP communication and examined some of the higher-level protocols such as TCP and RTP that use IP to transmit Web pages and video. We followed this with a look at multicasting, which is one of the key enabling technologies for IPTV. The Reality Check showed how large the market has become for broadband services and how much room exists for future growth. It's amazing to consider that essentially every broadband subscriber is a potential customer for IPTV or Internet Video.

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7. CIA Factbook https://www.cia.gov/cia/publications/factbook/geos/xx.html

6 Video Compression

Once you get past a few hundred kilobits-per-second, it's possible to deliver pretty good quality video and sound.

—Vinton Cerf

Video signals used in IPTV and Internet Video are almost always compressed. Compression means reducing the number of bits required to represent the video image. This is an important topic, because choosing a suitable compression method can sometimes mean the difference between the success and failure of a video networking project.

In this chapter, we will begin by examining the reasons for compression and look at some of the factors that determine what form of compression is suitable for an application. Then, we will examine MPEG video compression, since it is one of the most popular technologies used for video and audio compression. After that, we'll look at some of the other compression systems available for use with video and audio signals. We'll conclude with a look at some of the licenses needed to use some forms of compression technology.

The Corner Office View

[itvt]: What directions do you see [compression] heading in the near future?

Cooney: It's not difficult to see where it's going. Yesterday's compression technology was MPEG–2; tomorrow's compression technology is one of two options: MPEG–4 or Microsoft's VC-1. Both of those technologies, by about a factor of two, outperform MPEG–2. So, half the bit rate, double the channels—however you like to look at it.

CONTINUED ▶